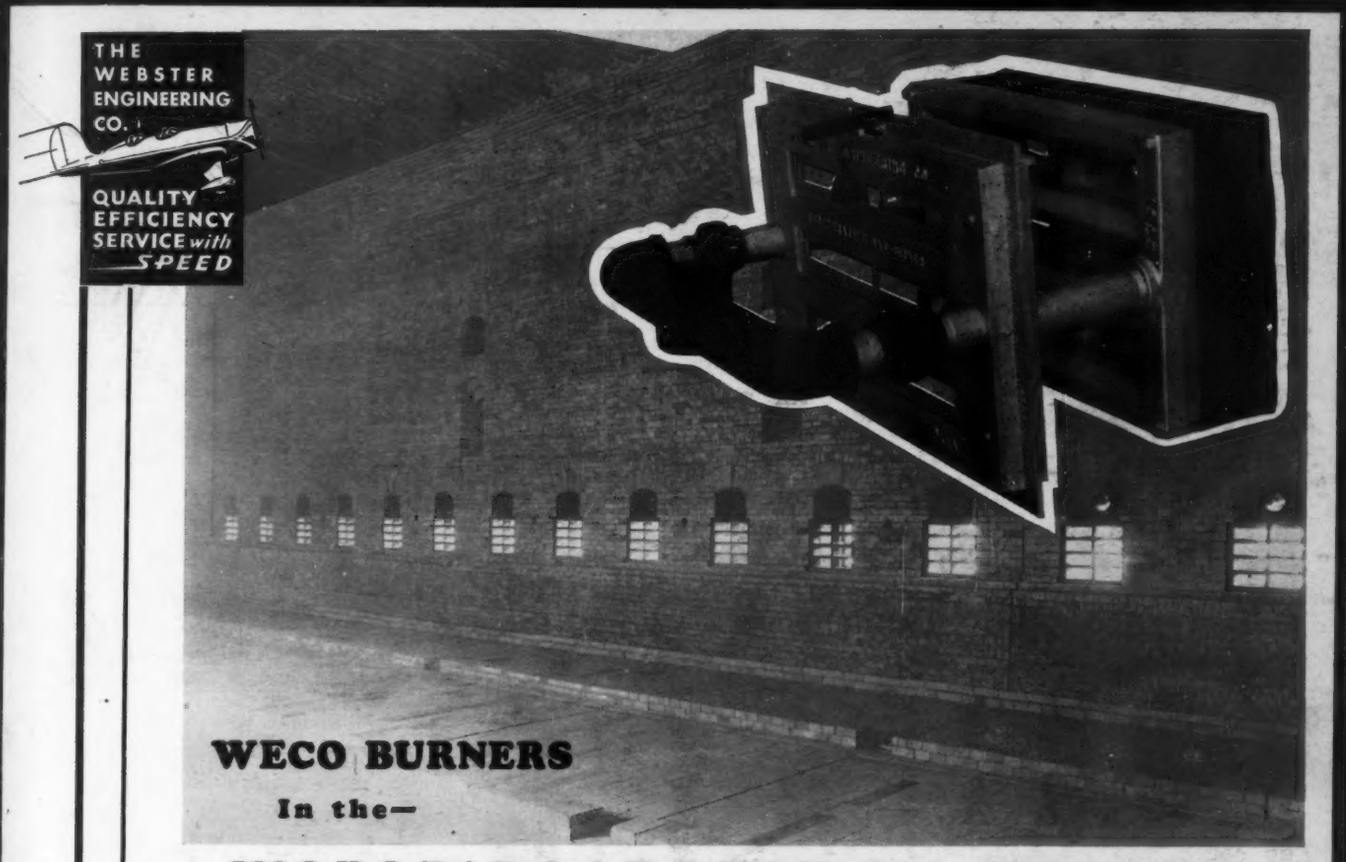


WORLD'S LARGEST OIL HEATER

Interior of Furnace 66 Feet Wide

There are 16 WECO NO. 700 SERIES GAS BURNERS *in* the above unit. WECO Burners were selected because of their complete control of flame characteristics and air control. Tests have proven highly satisfactory.

WEBSTER WINS AGAIN

THE WEBSTER ENGINEERING CO.

TULSA, OKLAHOMA

Division of Surface Combustion Corp., Toledo, Ohio

Sales and Service Organizations are: SURFACE COMBUSTION CORP., CHICAGO, CLEVELAND, COLUMBUS, DETROIT, KANSAS CITY, NEW YORK CITY, PHILADELPHIA, PITTSBURGH, ST. LOUIS; F. J. EVANS ENGINEERING CO., BIRMINGHAM; ED. TRAMMELL PUMP & MACHINE CO., OKLAHOMA CITY; NATURAL GAS EQUIPMENT, INC., LOS ANGELES AND SAN FRANCISCO; MECHANICAL EQUIPMENT CO., HOUSTON

$REWARD$

A reward will be paid for information leading to the location of a Still Tube made of LO-CRO-46-MO which has failed in service due to metallurgical defects.

In the April issue of the "REFINER," Mr. R. L. Duff, Metallurgical Technologist of the Standard Oil Development Company, ends his paper on "Metallurgy of Refining Equipment" with the following:

> ***"In one sense the alloy producers have the easiest part of the alloy game. Very few of them have first hand information as to the data that is printed in their catalogs and pamphlets, and woe be unto the consumer that accepts in good faith all that he reads. Many of the producers have 'pet' alloys that absolutely do not live up to their advertised qualifications."***

We know he is right. But with LO-CRO the difference is this: it is no "pet" but a full grown member of a famous family — Crucible's "REZISTALS".

LO-CRO is no metallurgist's dream or a "theory" on a graph. Thousands of tons have been made into tubes which have been in operation for years. One prominent engineer tells us that after 18,000 hours operating under very severe conditions using highly corrosive Venezuelan crude with a pressure of approximately 1,000 pounds, and a steel temperature around 1050 to 1100° F., he could find no measurable loss due to corrosion.

That's why so many Chief Engineers of the outstanding refineries not only specify but demand that their tubes be made from Crucible LO-CRO.

And this is not advertising or a cradle song for a "PET". We can prove it to you for the asking. Our imitators can suggest or claim "just as good"; show you curves of what 4-6 Chrome *should* do.

While efforts have been made to cheapen the mixture, not so with LO-CRO; we are increasing its cost through research, melting, fabrication and inspection. We apply tool steel practice to what some mills call "tonnage steel."

No "PETS" — all doing a he-man's job in most of the big up-to-date refineries in the country.

REZISTAL NCT-3
REZISTAL No. 4
REZISTAL 2-C
REZISTAL KA-2S
REZISTAL KA-2ST
REZISTAL 2600
REZISTAL STAINLESS IRONS
LO-CRO-46 MO W

CRUCIBLE STEEL COMPANY of AMERICA

General Offices: 405 LEXINGTON AVENUE, NEW YORK, N. Y.

Branch Offices and Warehouses:

ATLANTA
BALTIMORE
BOSTON
BUFFALO
CHICAGO
CINCINNATI
CLEVELAND
DENVER
DETROIT
INDIANAPOLIS
HOUSTON
MILWAUKEE
MOLINE
NEW HAVEN
NEW YORK
PHILADELPHIA
PITTSBURGH
PORTLAND, ORE.
PROVIDENCE
ROCKFORD
ST. LOUIS
ST. PAUL
SAN FRANCISCO
SEATTLE
SPRINGFIELD
SYRACUSE
MONTREAL
TORONTO

Rezistal Sheets Stocked and Distributed by:

A. M. CASTLE & COMPANY
Chicago, Los Angeles, San Francisco, Seattle

ELLFELDT HARDWARE & MACHINISTS' SUPPLY CO.
Kansas City, Mo.

ROSENFELDER MACHINERY CO., Inc.
Houston, Texas

REFINER
AND NATURAL GASOLINE MANUFACTURER

MAY, 1933
Vol. 12, No. 5

A Gulf Publishing Company Publication

EDITED MONTHLY AT HOUSTON, TEXAS

Copyright, 1933

GRADY TRIPLETT
Editor

GEORGE REID
Associate Editor

CONTENTS

Special Features

This Is the Bottom 161
An Editorial

Nickel and Nickel Alloys for Oil Equipment 162
O. B. J. Frazier

Meeting Some of the Problems of the Pressure Vessel User 174
T. McL. Jasper, O. E. Andrus and L. J. Larson

Characteristics of Steels at Elongated Temperatures 180
Francis B. Foley

Safety Drilling—Low Cost Insurance for Process Equipment ... 184
Joel H. Hirsch

Welding Corrosion-Resistant Iron and Steel 189
James Campbell Hodge, D. Sc.

Tube Wall Telescope for Examination of Interior of Tubes and Piping 198

Use of Instruments in Refining 200
V. R. Chadburn

Remodeling and Modernization of Holmes-Manley Cracking Equipment 203
C. M. Johnson

Regular Departments

Editorial 161

Science and Technology 28a

The Month in Review 37a

Plant Activities 42a

New Equipment for the Modern Plant 44a

Items About Manufacturers 50a

Catalogs and Bulletins 51a

SPECIALIZED OIL JOURNALS

Published by

GULF PUBLISHING COMPANY

OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *Gen'l Manager*
S. W. ROBINSON, *Editorial Director*
J. KENT RIDLEY, *Managing Editor*

NEW YORK, Room 323, 250 Park Avenue,
Dick Swinsky, Manager.

PITTSBURGH: 902 Standard Life Building,
W. W. Pigue, Manager.

CHICAGO, Room 1235, 141 W. Jackson Blvd.,
T. W. Nelson, Manager

LOS ANGELES, 416 Haas Building,
W. E. Green, Manager.

TULSA, 913-916 Hunt Building,
J. F. Carter, Jr., Manager.

FORT WORTH, 203 W. T. Waggoner Building
H. H. King, Manager.

Single copies 20 cents. Domestic and Foreign subscription price, $1.00 a year. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under Act of March 3, 1879. Advertising rates on application.

M·S·A HOSE MASKS

FIVE DISTINCT TYPES AVAILABLE

Safe ... comfortable ... easy to operate

PROTECT your men who must encounter deadly concentrations of gas or fumes in or around oil tanks, gas holders, tank cars and other similar locations with MSA HOSE MASKS, designed and made by the world's largest manufacturers of safety equipment.

Your men will welcome the comfort and convenience of MSA HOSE MASKS . . . easy to use,—offering full freedom while working yet assuring absolute safety under the most dangerous working conditions.

These fresh air outfits are mounted in the highest quality, waterproof, fibre cases and consist of the comfortable and gas tight Kops face piece, harness, hose and a hand or motor operated blower which supplies a steady, unfailing supply of fresh air. Five distinct types are available from a simple one-man outfit to those that furnish protection up to six men from one blower.

Write for our descriptive bulletin.

MINE SAFETY APPLIANCES CO.

General Offices: Pittsburgh, Pa.

District Representatives in Principal Cities

M. S. A. EQUIPMENT includes Breathing Apparatus . . . Inhalators . . . Masks of All Types . . . Gas Indicators . . . Eye and Head Protectors . . . Edison Mine Cap Lamps . . . Safety Clothing . . . First Aid Equipment . . . Descriptive Bulletins will be sent on request.

REFINER
AND NATURAL GASOLINE MANUFACTURER
A GULF PUBLISHING COMPANY PUBLICATION

VOLUME 12, No. 5 MAY, 1933

This Is the Bottom

AS black as the petroleum canvass is today, affairs of this industry are at their low ebb with nowhere to go but up. It is impossible to bring the price of East Texas crude oil sufficiently below its current figure to cause much additional damage to the market. A price posting of 10 cents a barrel with substantial purchasers paying the "going price" leaves the bottom within the reach of the sourest pessimist. It would take only a whisper for purchasers to say they want no more crude oil.

It will be no surprise if the pitiful crude oil market causes no drop in gasoline prices. These, like the crude oil price structure, are so low they are a small factor. When the price of crude oil is less than 50 cents a barrel the cost of raw material has scant relation to cost of production.

This East Texas field has been riding the petroleum industry for three years. The refining plants of the world have been operating at a loss because this one field could produce more oil than the world needed or the financial experts of the industry cared to buy. Meanwhile, holders of leases have continued to drill properties. A small minority has given no allegiance to restricted output, despite the fact that it would have brought greater return than the present abnormal output.

If the flowing life of the pool were known, it would be possible to project a curve to the point where the petroleum industry will take its upturn. Engineers are not in accord on this. Some estimate that the field can flow another 300,000,000 barrels of crude oil. On that basis it will require a year to get the field out of the way.

But the question arises concerning the likelihood of such a flow.

Obviously the world can not consume that oil plus the oil from other areas. So unrestricted flow means the building of additional storage. So far that move has not been started. Purchasers seem reluctant even to fill existing storage regardless of the low prices.

There is also the human element. Perhaps 95 per cent of the producers in that field are in favor of a uniform output of lower figure plus a higher daily income. So far the five per cent has overpowered the 95 per cent. There is no legal machinery by which the majority can gain its objective.

The output of 750,000 barrels daily at the beginning of May was fixed by the Texas Railroad Commission in the hope that the order of proration would meet the approval of the courts. Texas has pending a measure to make violation of a proration order a felony. If the proration order can be given legal rating and the felony law added as support, there is some hope for early control of the field politically.

Another question concerns the willingness of property owners to turn their assets into other hands at a loss. An oil well producing 75 barrels of oil a day at 10 cents or less per barrel is a liability. Even those with utter disregard for laws should see the folly of such procedure. If this five per cent can be convinced that the end of this move is bankruptcy, there is hope on that score.

But whether the field is allowed to go until normal decline gets the upper hand, or the government of Texas finally gets strong enough to protect industry, or willful wasters begin to use paper and pencil, the change that comes will mark the upturn in petroleum affairs.

Refiners may then begin to look for the day when there will be a profit in processing crude oil.

Provided, of course, that someone does not uncover another East Texas.

Nickel and Nickel Alloys ... *for* Oil Refinery Equipment

O. B. J. FRASER

Development and Research Department, International Nickel Company, Inc.

PETROLEUM refining practices of today call for the utmost in performance of metallic materials used in almost all of its operating equipment. Chemical stability in all kinds of corrosive environment, and superior physical properties under adverse conditions of temperature and pressure are more than ever essential to the maintenance of the industry under currently existing competitive conditions.

Mr. O. B. J. Fraser, author of the accompanying article was formerly in charge of the research laboratory for International Nickel Company, at Bayonne, New Jersey. He was recently transferred to the company's main offices in New York, where he is in charge of development in the uses of nickel and nickel alloys in the oil, gas and coke industries.

METALLURGICAL SYMPOSIUM

PETROLEUM refining practices of today call for the utmost in performance of metallic materials used in almost all of its operating equipment. Chemical stability in all kinds of corrosive environment, and superior physical properties under adverse conditions of temperature and pressure are more than ever essential to the maintenance of the industry under currently existing competitive conditions.

From the standpoint of tonnage used, simple carbon steels still occupy the premier position, but refinery engineering is relying more and more heavily as time goes on upon alloys—both ferrous and nonferrous. It is no exaggeration to say that it would be practically impossible to refine many of the corrosive crudes now being utilized, were it not for contemporary metallurgical developments which have provided the necessary materials of construction.

MONEL METAL

Nickel alloys are no newcomers in refinery operations, particularly in those located on the seaboard, where seawater is used for cooling and condensing. A refinery in the New York district found, in tests begun in 1908, that Monel metal bolts outlasted anything else available in the joints of cast iron condensers cooled with seawater. Some 50,000 of these bolts were placed in the condenser banks in 1910 and more were used in new banks installed in following years. Some of the first bolts were taken out and critically examined in 1931. In the 21-year interval of exposure to New York Harbor waters there had been practically no alteration from the original condition. A Gulf Coast refinery has had a similar experience extending over a shorter period of some 16 years. Here steel bolts lasted only six to eight months. Physical properties, as well as corrosion resistance, are important in determinnig the choice of bolt materials. Table 1 contains the results of a set of impact tests in which bolts were broken in tension by a single blow.[1]

Monel metal rods are used in great number in pumps handling light oils and distillates at moderate temperatures. Monel rods are used also in water pumps and they are particularly useful for pumps handling hot acid sludge. In one pump the rods were in very good condition after 10 months continuous service pumping acid sludge at 300°F. against 125 pounds per square inch pressure. Gas compressor and pump valve parts of Monel metal are used very generally.

Monel metal trimmed valves are in regular use for high pressure steam service and in lines handling caustic solutions, hot salt water and dilute acids. Its non-galling characteristic is valuable in steam service. Many all-Monel valves are used for acid control. Valves with Monel trim are used for controlling the flow of oils at moderate and low temperatures and are particularly useful for oils which contain small amounts of caustic or acid following chemical treatment. Mixed results are obtained with hot oils. Some refineries use Monel trimmed valves in hot oil lines where temperatures above 1000° F. are met with occasionally, whereas in other cases, notably where the oil is high in sulfur, better results are obtained with stainless steel trim.

Nozzles and burner tips are somewhat related in function. A number of oil tankers are equipped with Monel metal spray nozzles in their fire extinguishing

TABLE 1

Tension impact tests on 5/16 in. x 2¾ in. bolts results in ft. lbs. required for rupture by a single blow.

MATERIAL	Number of Threads Exposed		
	1	3	12
Monel Metal	60 ft. lb.	60.25 ft. lb.	95.5 ft. lb.
Steel (low carbon)	44	48	70
Naval Brass	20	32.5	66.5
Bronze (1.15% Tin)	30.5	31	47.5

systems. An English company uses Monel metal tips on oil burners and a very recent development has been the application of a modified Monel metal casting composition for sludge acid burner tips. This material can be hardened by heat treatment after machining, to a Brinell hardness of 350 or more. This hardness, coupled with the inherent chemical stability of Monel metal, provides excellent resistance to the abrasive action of the coke particles and to the corrosive action of the acid in the sludge. A forgeable modification of Monel metal, which can be heat treated to a Brinell hardness of 300 to 350, is also available.

Monel metal sheet has many uses in refineries. Outstanding is the lining of various large pieces of equipment for resistance to hydrochloric acid corrosion. Bubble towers have been so lined and so also have the vapor space and run down lines of fractionating stills, and other vapor lines. Perforated Monel sheet has a life of about four years when used to support activiated carbon in the absorption of casing head gasoline from natural gas. Sweater pan liners of Monel metal have also been successful. So also have been the bowls of dewaxing centrifuges which have to resist the erosive action of hot water jetted against the neck of the bowl to act as the carrier liquid on which the wax floats within the bowl.

Monel metal wire cloth is used for sweater pan screens, for support screens in Gray process towers, where rather severe temperature conditions have to be met, for tank vents and for filtering all types of oils and distillates, and corrosive solutions.

Monel metal welding wire is used in considerable quantities, not only for welding Monel metal, but for welding cast iron.

Seamless Monel tubing is used in one refinery in overflow towers in their sulfuric acid plant. Both Monel metal and nickel tubing are highly resistant to caustic solutions, for which they have had considerable use in refineries. Monel metal coils have given excellent service in chlorination vessels in which linings and agitator shafts are also of this alloy.

COPPER-BASE ALLOYS OF LESS THAN 50 PER CENT NICKEL CONTENT

Considerable use has been made in condensers and heat exchange equipment in the petroleum and other industries of some of the copper-nickel alloys containing less than 50 per cent of nickel. These are relatively low cost materials which in tubular forms possess excellent mechanical properties and resistance to corrosion. In particular they do not suffer from selective corrosion of the type known as dezincification in brass.

Probably the best of these for all round usefulness is that containing 30 per cent of nickel and 70 per cent of copper. Its mechanical properties at elevated temperatures are superior to those of the bronzes. It has been in use for years in marine condensers and all the newer large trans-Atlantic ships have their condensers equipped with tubes either of this alloy or of modifications of it. Tests in one Gulf Coast refinery indicated a life for tubes of 20 per cent nickel content of about five times that of Admiralty metal tubes in the particular unit in which the test was run, and the same material is being used with success in a Mid-Continent refinery. In another refinery, tubes of the 70-30 alloy are giving excellent service in a shell and tube heater for preheating acid sludge for burning.

Other alloys which have merit for heat interchange units or tubular condensers are a copper-nickel alloy

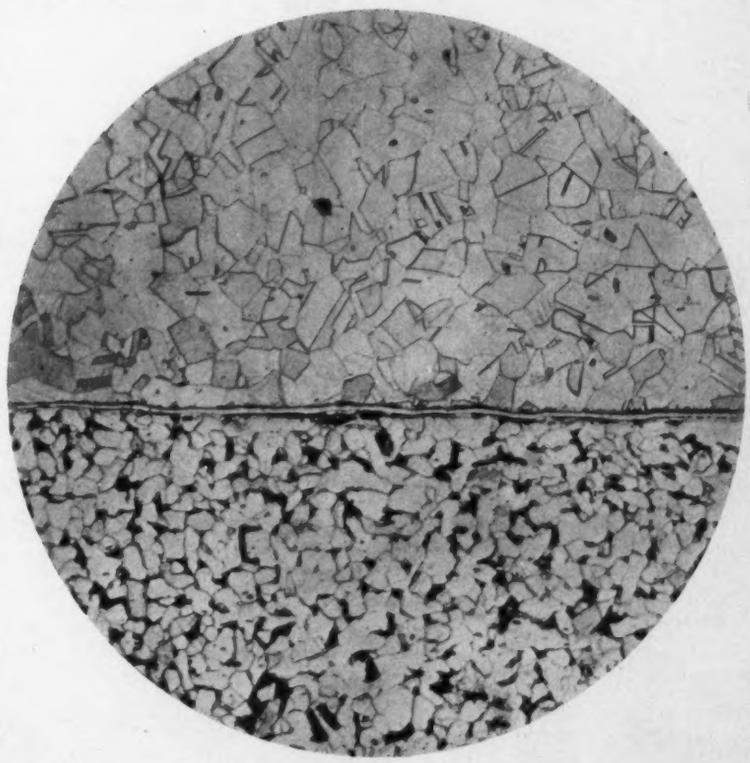


FIGURE 1

Photomicrograph of bond between Nickel and Steel in Nickel-clad Steel Plate. The upper portion is Nickel.

and a copper-aluminum-nickel alloy each of which contain four per cent of nickel.

Complete data on properties of all of these alloys are not available. A good idea of the nature of some of them can be obtained, however, from Tables 2[2] and 3[2-3]. In addition to the data therein contained, some figures are available on endurance limit[4] of the 80 copper—20 nickel alloy. This is 18,000 pounds per square inch for cold rolled material and 16,000 pounds per square inch for annealed material.

INCONEL AND NICKEL CLAD STEEL

Two materials of recent development should find numerous applications in refinery construction. Inconel, a chromium-nickel alloy, containing about 14 per cent of chromium is highly resistant to carburization and to a great many corrosives. It is more resistant to sulfurization than either nickel or Monel metal and is also more resistant than those materials to many aqueous corrosives. It has excellent physical properties, as is evidenced by the data in Tables 4 and 5 and is produced in the same mill forms and finishes as nickel and Monel metal. It is an excellent casting alloy also. It is especially interesting to note that its coefficient of thermal expansion is 7.2×10^{-6} per degree Fahrenheit, the same as that of steel, and its modulus of elasticity in tension is 31,000,000, or somewhat greater than that of steel; in other words it is slightly more rigid than steel. Inconel is a very tough material, showing Charpy impact test values averaging 200 foot pounds energy absorption without fracturing the test-piece. This toughness is greater than that of the steels and other nonferrous alloys. Welds in Inconel are made readily and are sound, strong and ductile. There is no structural deterioration due to heating such as has been known in the past as weld decay in certain iron-base alloys. As trim in steam valves Inconel has demonstrated excellent resistance to wire drawing.

TABLE 2

Mechanical properties of .623 in. O.D. x .048 in. wall copper-nickel alloy tubes.

Composition—%		Annealing[1] Temp. °F.	Max. Stress lb./in²	Prop. Limit lb./in²	Elongation % in 2 in.
Cu	Ni				
80	20	As drawn	71,500	15,700	10
		482	70,800	22,400	10
		1382	55,600	11,200	43
70	30	As drawn	83,300	17,900	9
		482	81,100	23,500	16
		1382	61,800	13,450	44

TABLE 3

Short time mechanical properties of tubing alloys at elevated temperatures.

ALLOY	Composition				Temp. F.	Tensile Str. lb/in²	Prop. Limit lb./in²	Elong. % in 2 in.
	Cu	Ni	Zn	Sn				
Cupro-Nickel.....	80	20			60	59,600	47,900	30.5
					392	52,600	38,300	27.5
					752	45,500	35,850	22.0
					1112	36,100	29,350	9.5
Ambrac.....	65	30	5		20	91,500	48,000	17.5
					400	81,000		15.0
					600	78,000	38,000	9.5
					800	65,000	18,500	15.5
					1000	48,500	3,500	12.5
Admiralty.....	70		29	1	20	51,000	13,000	70.5
					400	50,500	8,000	60.5
					600	40,500	7,500	54.5
					800	25,500	5,500	23.5

TABLE 4

Mechanical properties of Inconel at normal temperatures.

FORM	Tensile Str. lb./sq. in.	Yield Point lb./sq. in	Elong. in 2 in. %	Reduction in Area %
Sheet, annealed....	80– 95,000	30–40,000	45–55	
Rod, Annealed....	80– 95,000	30–40,000	45–55	65–75
Rod, Cold Drawn..	100–115,000	80–95,000	20–30	

TABLE 5

Short time mechanical properties of Iconel at elevated temperatures.

Temperature °F.	Tensile Str. lb./sq. in.	Elong. in 2 in. %	Reduction in Area %
Normal	90,000	55	75
600	90,000	55	75
800	85,000	50	60
1000	72,000	45	50
1200	60,000	27	27
1400	46,000	11	14
1600	27,000	18	22
1800	15,000	35	40
2000	8,400	75	80
2200	5,000	100	100

The other recently developed material is nickel-clad steel plate. This consists of a mild steel base to which is bonded, by a hot-rolling process, a surface layer of pure nickel. Through thermal diffusion a solid-solution alloy is formed at the interface, and a permanent and inseparable bond results. The two metals are actually welded together in the process of manufacture, but at a temperature below the fusion point of either. The result is a material possessing the familiar fabricating characteristics of steel plus a surface with the chemical stability of pure nickel, at a cost much closer to that of steel plate than to that of nickel. The nickel is free from pores and hence the protection afforded the steel base is perfect. The thickness of the nickel layer normally ranges from 10 to 20 per cent of the total plate thickness. The range of thickness in the composite plate is from 3/16-inch to one inch, and a wide range of sizes is available up to 144 inches in width. The maximum length in that width is 200 inches for 9/16-inch plate.

The thickness of the nickel layer is dictated by the conditions of corrosion, erosion and abrasion which have to be met. The material can be sheared, bent, flanged, formed, etc., like ordinary steel plate. In heating for hot working it is necessary to bear in mind that the usual precautions required for heating nickel must be observed.

The continuity of the nickel surface must be maintained in fabricated equipment. This is accomplished in riveted lap joints by using pure nickel rivets plus calk welding of the open seam with pure nickel welding wire. Butt and lap welded joints are made by the metallic arc method using steel filler rod on the steel side and pure nickel on the nickel side. The carbon arc,

acetylene or atomic hydrogen methods of welding also may be used.

Suggested uses for nickel clad steel would be shells of fractionating towers and other equipment handling corrosive fluids, "sour" distillates for example; tank bottoms; tank roofs; caustic and acid treating equipment; etc. Nickel clad steel drums and barrels are already in use for shipment of aviation gasoline. Condenser shells might also be made of this material.

LOW ALLOY NICKEL STEELS

Steels are alloyed with other elements for either one or both of two purposes, namely, to obtain special values for physical properties, or to improve resistance to corrosion. For improved mechanical properties the alloy additions are usually not greater than five per cent of any one element. Nickel enters into such a great number of the alloy constructional steels that only those of special interest to the refining industry can be dealt with here.

There is relatively little use made of the simple nickel steels in refineries, but these possess some unique properties which it would seem would make them very useful for certain special applications. The excellent toughness and resistance to aging possessed by steels containing 0.15-0.20 per cent of carbon and 2.00-2.25 per cent of nickel have made them very popular with many of the railroads for boiler construction. Nickel alloy steels also possess, in marked contrast to carbon steels, the characteristic of retaining down to sub-zero temperatures, a large proportion of their initially high impact strength. The pearlitic steels containing from two to five per cent of nickel are very tough at temperatures down to as low as —100° F. For example, at that temperature the Charpy impact value for a plain steel of 0.32 per cent carbon content, furnace cooled from 1500° F. and drawn at 1200° F., is only 2.5 foot pounds against a value of 44 foot pounds for a 3.5 per cent nickel steel containing 0.10 per cent of carbon and similarly heat treated. At 75° F. these two steels have values of 24 foot pounds and 56.5 foot pounds, re-

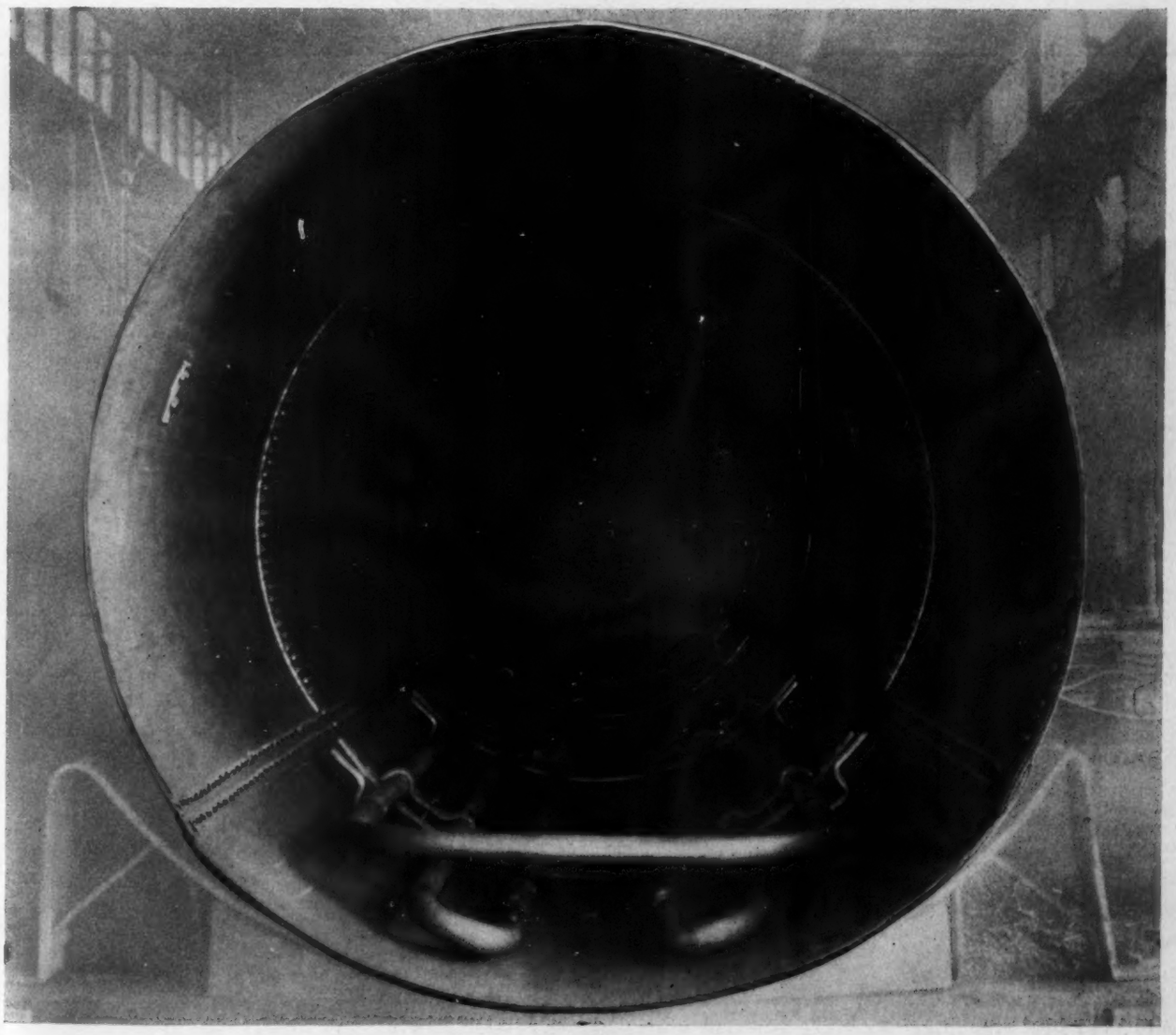


FIGURE 2

Interior of nickel-clad steel tank car in process of construction. The coils are solid seamless tubing.

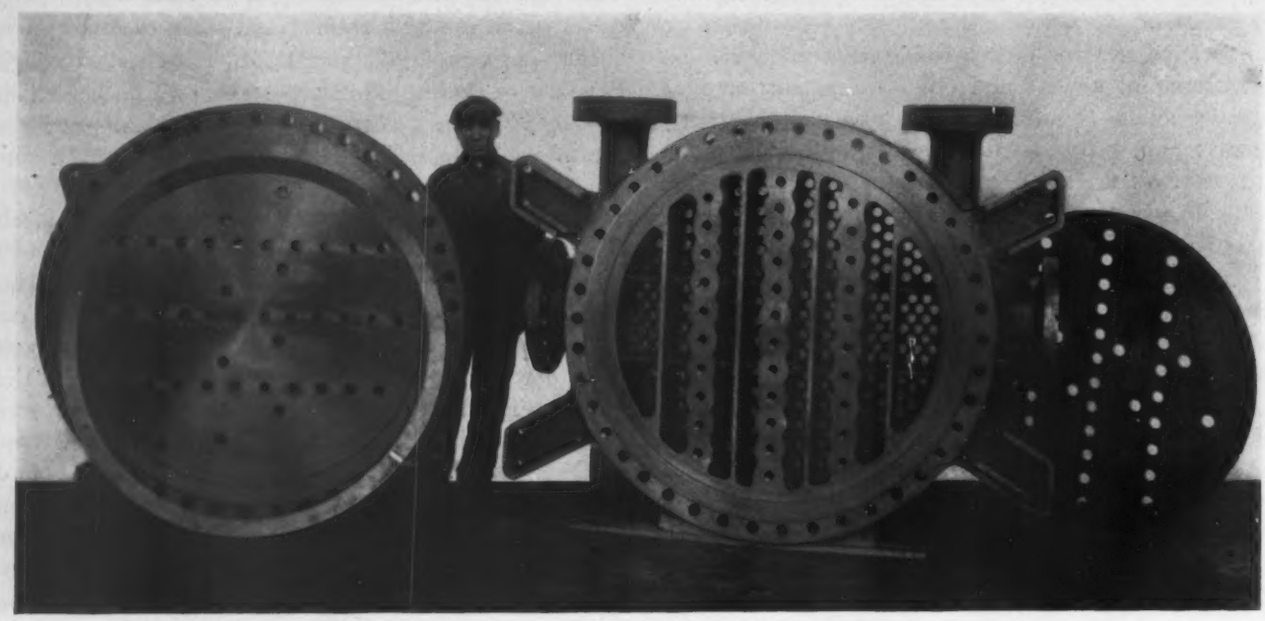


FIGURE 3

Nickel-chromium steel channel castings for the base of a vapor heat exchanger for oil refinery service at 800°F. and 1,500 pounds per square inch pressure.

spectively[5]. The Canadian railroads have taken advantage of this characteristic in using the nickel steels in rolled or forged form for vital parts of locomotives. It should be of interest also for dewaxing and refrigerating equipment and for tanks in the colder regions where sudden failures have been experienced more than once under conditions of fairly rapid changes of temperature in the sub-zero ranges.

Nickel-chromium steels of the SAE 3100 series, containing 1.0-1.50 per cent of nickel and 0.45-0.75 per cent of chromium are used for bolts and studs in such equipment as valves, hot oil pumps, and reaction towers. SAE 3130 steel is much used for these purposes. Typical physical properties,[6] following a suitable oil quench and draw, are given below:

Tensile strength	136,000 lb./sq. in.
Yield Point	118,000 lb./sq. in.
Elongation in 2 in.	22 %
Reduction of Area	65 %
Endurance limit	61,000 lb./sq. in.
Charpy impact	52 ft. lb.

This heat treated steel possesses a high yield point and endurance limit. It also shows excellent shock resistance and in addition it has good resistance to creep at high temperatures, the safe creep stress for a limit of three per cent at 1000° F. being close to 11,000 pounds per square inch. Cast nickel-chromium steel valves fitted with bolts of this material are used on oil lines—in many refineries at extremes of 900° F. temperature and 1350 pounds per square inch oil pressure.

Plungers for direct acting hot oil pumps are made of SAE 3340 steel containing 3.25-3.75 per cent of nickel and 1.25-1.75 per cent of chromium.

Cast nickel bearing alloy steels of a number of compositions are in use. A steel containing 1.0-1.50 per cent of nickel and 0.45-0.75 per cent of chromium, with 0.35 per cent of carbon (SAE 3135) is much used for valve bodies. Another popular steel for valve bodies and fittings is one containing 1.75-2.25 per cent of nickel, 0.70-0.90 per cent of chromium and 0.30-0.35 per cent of carbon, which shows the following normal temperature properties after heat treatment:

Tensile Strength	100,000 lb./sq. in.
Yield Point	65,000 lb./sq. in.
Elongation in 2 in.	18-25 %
Reduction in Area	38-45 %
Brinell Hardness	200-225
Charpy Impact	16-20 ft. lb.
Endurance Limit	40,000-50,000 lb./sq. in.

This steel has a three per cent safe creep limit of 11,000 pounds per square inch at 1000° F. It is the steel used for the bodies of the refinery valves mentioned above in the discussion on bolts.

Return bends for cracking stills are cast in at least two low alloy compositions, both of which afford service superior to that of plain carbon steels. One composition is the heat treated SAE 3130 type cited above. This and other alloys of the 3100 series are used for many other types of refinery castings. Likewise for return bends and for many other types of castings, such as those for high temperature—high pressure heat exchangers, a great deal of use is made of the steels containing about 2.0 per cent of nickel, 0.80 per cent of chromium, 0.70 per cent of manganese, 0.30 per cent of silicon and 0.35 per cent of carbon. When normalized at 1700-1750° F. and drawn at 1100-1150° F. these steels have approximately the properties given above.

Cast nickel-chromium-molybdenum steels containing

about 1.75 per cent of nickel, 0.70 per cent of chromium, 0.20 per cent of molybdenum, are widely used for high temperature service. This type of composition is more resistant to creep at 1000° F. than the straight nickel-chromium type.

Properly heat treated nickel-chromium-molybdenum steel castings containing about 1.75 per cent of nickel, 0.75 per cent of chromium, 0.40 molybdenum and 0.55 carbon are highly resistant to abrasion and hence are well suited for pumps handling gritty fluids. In a vital part of a dredging pump, subjected to heavy abrasion, a heat treated nickel-chromium-molybdenum steel gave five times the service of carbon steel.

Some use is made of a simple nickel steel containing 0.80 to 1.0 per cent of nickel and 0.30 per cent of carbon for castings for hot oil pumps which reach a cherry red heat in operation.

Alloy steel castings have a very definite place in refinery engineering, but must be accorded reasonable respect for their limitations. A single specified composition cannot be founded economically into any and all designs of casting, and once cast the proper heat treatment must be given to obtain the desired service. These are questions which call for close cooperation between manufacturers and purchasers of castings.

A recent development in low alloy steels is the addition of nickel in suitable amounts to nitriding steels.[7] The nitrided nickel steels have a harder and stronger core and a tougher case than the non-nickeliferous alloys. An added improvement is obtained in compositions containing both nickel and aluminum. These exhibit dispersion hardening at the nitriding temperature and resultant great increase in hardness, strength and elastic properties of core, at the expense of some decrease in ductility and impact strength.

HIGH ALLOY NICKEL STEELS

High nickel alloy steels are used in large quantity in refining operations, for their corrosion resistance in some cases but in largest amount for their load carrying ability and resistance to sulfurization and oxidation at high temperatures. This is not a set of properties conferred by nickel alone, for these alloys always contain large amounts of chromium as well, and frequently also

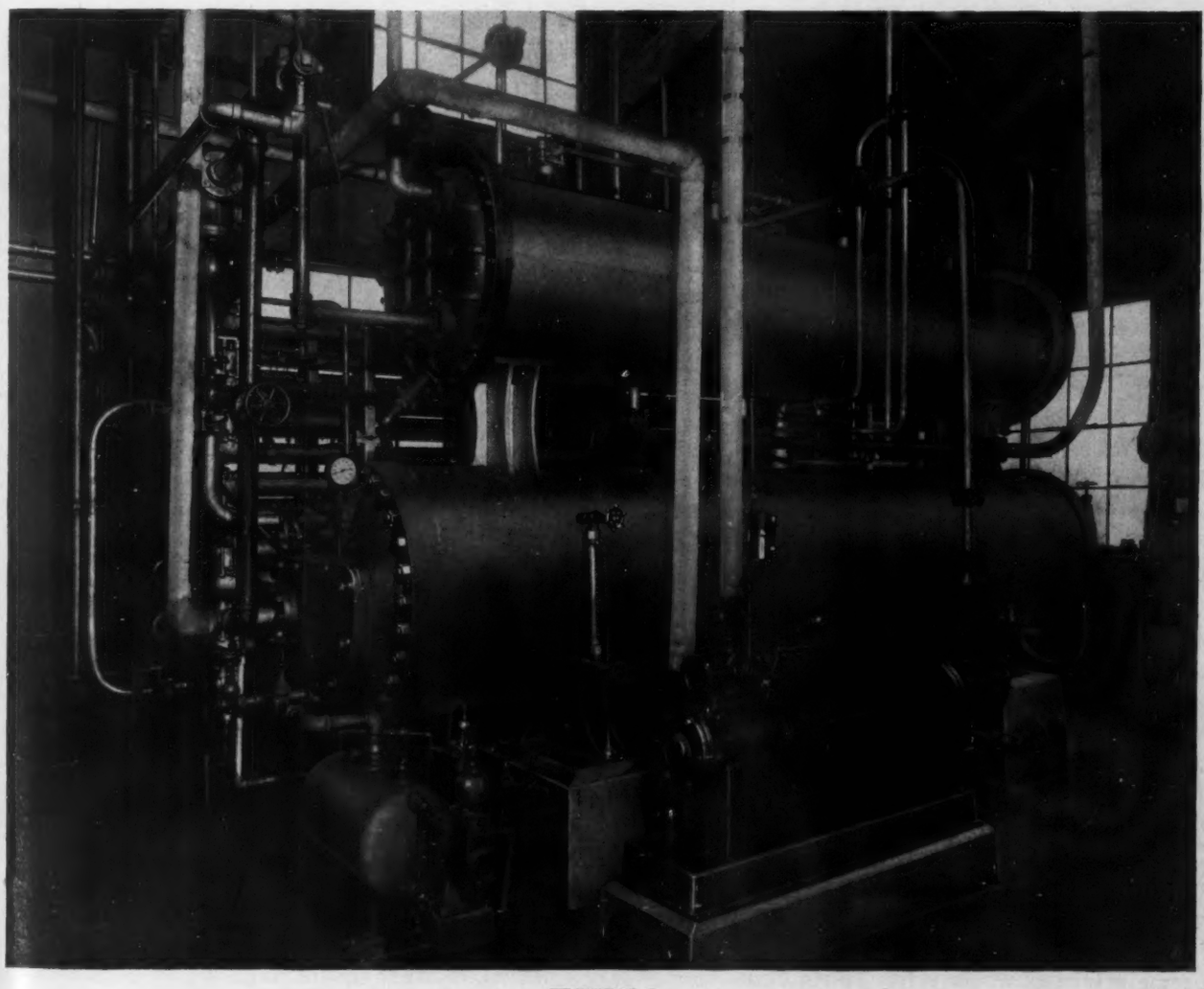


FIGURE 4
Refrigerating machine in a middle-states refinery. The lower large cylinder is of nickel cast iron.

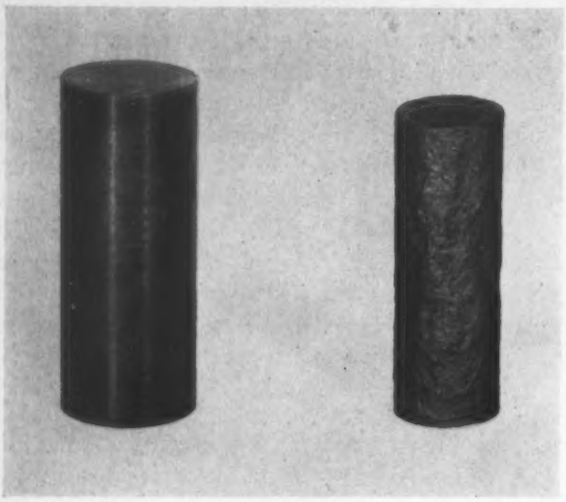


FIGURE 5

Ni-Resist (left) and plain gray cast iron after one week in five per cent sulphuric acid at room temperature.

tungsten, and/or molybdenum, or other elements. Some also contain aluminum.

The high nickel-chromium steel used in largest quantity in the wrought form is, of course, the familiar austenitic 18-8 composition produced under a variety of trade names. This alloy contains 18 per cent of chromium and eight per cent of nickel. Though lower cost plain carbon or low alloy steels are used in much larger tonnage than this composition for cracking still tubes, there are many refineries where, because of the highly corrosive crudes being run, or because of a particular type of operation, it is found necessary to use the 18-8 alloy for radiant section cracking tubes and for transfer lines. There have been a few premature failures probably due to local overheating, but those long experienced in operation of cracking stills equipped with 18-8 tubes have found that if reasonably close inspection and careful operation be accorded, so that tube wall temperatures are never allowed to go above 1250° F., there is little or no danger of tube failures.

Some use has been made of 18-8 tubing in smaller sizes in high temperature, high pressure heat exchangers and in condensers. A considerable quantity of this alloy is used for trim on hot oil valves, piston rods on reciprocating pumps, shafts on centrifugal pumps in hot and cold oil service, valves and valve springs in hot oil pumps up to 500° F., valves in gas compressors, and still plugs. Forged headers, or return bends, are made of it, and it has been used in cast form for compressor ends, liners, etc., in gas compressors.

A steel containing 20 per cent of nickel, 8 per cent of chromium and 1 per cent of silicon has been used in some refineries where it has shown even better high temperature properties and corrosion resistance than the so-called 18-8 alloy. It has given excellent results in either the wrought or cast form for such purposes as cracking still tubes, valves, pumps and pump rods, and still plugs. In one seaboard refinery it has given very good service in the cast form as impellers in harbor water pumps.

For certain very special cases, where conditions call for very high resistance to severe high temperature operating conditions, tubes of more highly alloyed composition have been used. These have been made of such alloys as 24 per cent chromium—12 per cent nickel and 25 per cent chromium—20 per cent nickel.

Heat resisting alloys in the form of castings are made in a wide range of compositions, and offer material for a complete article in themselves. The alloys vary in the relative proportions of the component elements, depending upon the service to which they will be subjected, but all fall within the limits of 5 to 38 per cent of nickel with 7 to 35 per cent of chromium. As noted above they may also contain aluminum or one or both of tungsten and molybdenum. Their principal use in petroleum refining equipment is as tube supports in the hottest parts of the cracking furnaces, where their resistance to oxidation and sulfurization and their load carrying capacity at high temperatures are all brought into play.

LOW ALLOY CAST IRON

Alloy cast irons are a practical development of the past 10 years only, during which time they have come into general industrial application. Like the steels they can be divided into two groups, the division between which may be arbitrarily placed at about 5 per cent of total alloy addition. Below that level the alloying improves physical properties greatly and chemical and structural stability to a lesser degree. Higher alloying is chiefly but not solely for the purpose of improving corrosion resistance and structural stability.

Gray cast iron may be considered as a mixture of steel and graphite and in many respects alloy additions have the same types of effects on it as upon steel. Nickel and small amounts either with or without properly proportioned chromium additions, increases greatly the strength, toughness and wear resistance of gray iron, reduces chilling tendency and provides a uniformly increased hardness coupled with better machinability. Graphite flakes are smaller, grain size is finer and more uniform, and brittle white spots are eliminated. Ordinary gray iron gradually becomes unmachinable at Brinell hardness values above 180, whereas suitably alloyed nickel cast irons are still machinable at hardnesses as high as 350 Brinell. The exact composition of iron to use varies with the nature of the base iron which a foundry may be running, and also with the type and thickness of the casting and the mechanical properties desired in it. These are factors for cooperation between producer and purchaser.

Common gray iron has a tensile strength of less than 30,000 pounds per square inch. Alloy irons containing from 0.75 to 2.0 per cent nickel, 0 to 0.60 per cent of chromium and carbon, manganese and sillicon varied to suit the thickness of casting or the hardness desired,

have tensile strength values from 25,000 to 48,000 pounds per square inch. A special grade of high strength cast iron, which has been trade named Ni-Tensyliron, and which contains 2 per cent of nickel and appropriate carbon and silicon contents, have a minimum tensile strength of 50,000 pounds per square inch and transverse strength of 4500 to 6000 pounds per square inch. It also has Izod impact test values measured with a light-weight hammer of 24 to 30 feet pound, as compared to only 7 or 8 feet pound for ordinary gray iron. Properties of other low alloy nickel-chromium cast irons can be improved by heat treatment to such values as are given below for a malleable type, namely:

Tensile strength	85,000 to 100,000 lb./sq. in.
Yield point	70,000 to 75,000 lb./sq. in.
Elongation	8 to 15 per cent
Brinnell hardness	220-240

The low alloy irons have found many uses in refineries. Some in the east have been using them in quantity for bubble caps and trays, and large tonnages are used in the Middle West and Mid-Continent for lower still tube supports which are still in good condition after three years service, where plain cast iron lasts only one year. The metal temperatures probably are no greater than 1000 ° F., though the furnace gas temperatures, of course, may be several hundred degrees higher. In using these alloys at elevated temperatures it must be borne in mind that they are in no sense heat resisting alloys. As compared to ordinary cast iron they are stronger at all temperatures up to the limit of their usefulness and in addition they possess slightly more resistance to scaling and much greater structural stability. Under pressure conditions these irons may be used at temperatures up to 600° F. and pressures up to 250 pounds per square inch.

The Ni-Tensyliron type of material is used for pressure castings, superheated steam castings, cylinders and liners, cylinder heads, pistons, piston rings, machinery frames, gears and pinions, sprockets, cams, couplings, drums, pipe and fittings and valve bodies. One large refinery is using it extensively for pump bodies or casings, impellers, liners and pistons; for compressors and for high pressure valves. A suggestive list of applications for the lower strength alloy irons in which they have proved their usefulness comprises oil burner parts; pipe and fittings; valves; expansion joints; pistons and piston rings; plungers; pump castings and impellers; pump and cylinder liners; bushings; blow cases; chemical castings; pressure castings; ammonia and refrigerator castings; gratebars; stoker parts and superheater castings; steam chests and cylinders; heat exchanger shells; condenser chests and jackets; pump and compressor cylinders; compressor heads and parts; Diesel, gasoline and steam engine cylinders and parts; exhaust manifolds; electrical and power plant equipment; and general machinery parts.

Some specific examples should be interesting. Ammonia compressor parts of cast iron containing 3 per cent of nickel were still in active service after 18 months as against only two months for plain cast iron. Some Diesel engine cylinder liners of low nickel-chromium cast iron were in service for three years in an engine which was partially equipped with plain iron liners, the latter requiring replacement in from six to nine months. Low alloy iron piston rings lasted 13 months in gasoline pumps as against only six weeks for plain gray iron, and in addition prevented previously occurring

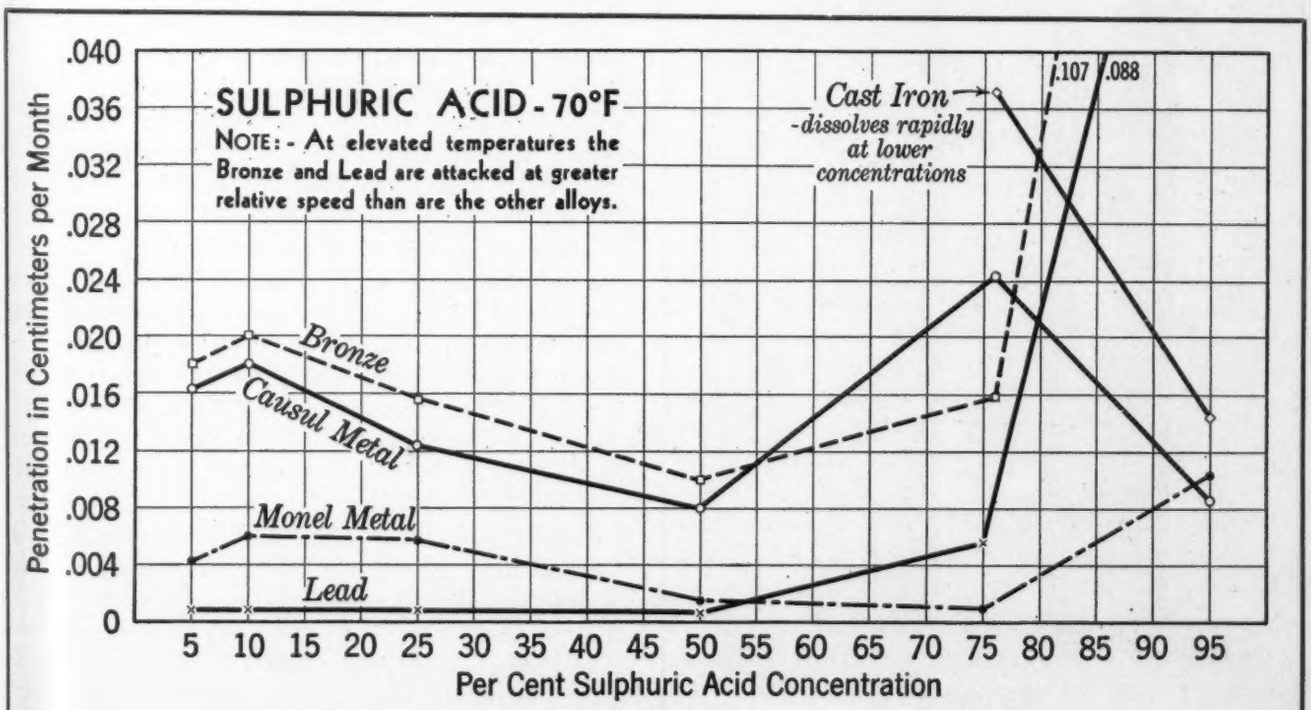


FIGURE 6

Corrosion rates of valve construction materials in sulphuric acid solutions at 70° F. (Lunkenheimer Company) "Causul metal" is a special grade of alloy of the Ni-Resist type.

leakage of fairly large quantities of gasoline. One manufacturer uses up to 3 per cent of nickel with up to 1 per cent of chromium in pump castings for water, gasoline, kerosene, fuel oil residuum, foam solutions, etc. Another uses a low nickel content in all pressure castings, liners, pistons and gears for hot oil pumps used at temperatures up to 700° F. An eastern oil company obtains from a similar composition for liners and rings in hot oil pumps about five times the life of ordinary gray iron. For service against caustic liquors, cast irons with either 2 to 5 per cent of nickel or with 3 per cent of nickel and 1 per cent of chromium are in regular use.

HIGH ALLOY CAST IRONS

One of the members of this class is used practically entirely for its strength, hardness and wear resistance, although it does possess very much greater corrosion resistance than plain iron. This renders added service in special cases. It is a chilled iron which has been tradenamed "Ni-Hard" and is produced usually by adding from 3.0 to 6.0 per cent of nickel and 0.5 to 2.50 per cent of chromium to a regular chilled iron base composition.

For most purposes the alloy composition is 4.5 per cent of nickel and 1.5 per cent of chromium. Table 6 gives the properties of low and high carbon plain and alloy chilled iron.

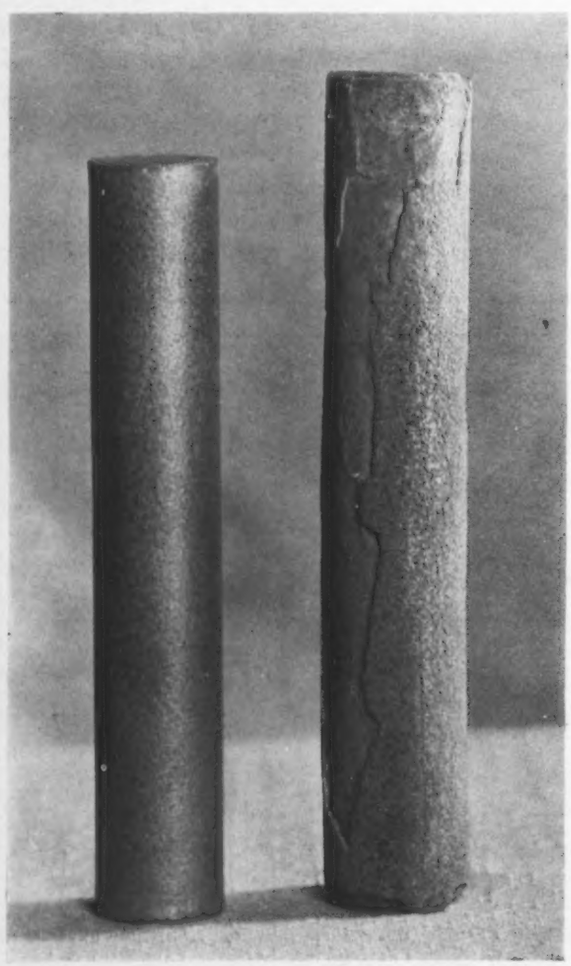


FIGURE 7

Relative growth, oxidation and warpage of Ni-Resist (left) and plain gray cast iron after repeated heatings to 1,500°F.

TABLE 6

Properties of plain and alloyed chilled iron

	High Carbon		Low Carbon	
	Plain	Alloyed	Plain	Alloyed
Brinnel on chilled surface	500	650–700	400	575
Tensile strength of grey core	25,000psi	30,000psi	30,000psi	40,000psi
Total Carbon	3.50%	3.50%	2.75%	2.75%
Silicon	0.75%	0.75%	0.75%	0.75%
Nickel		4.50%		4.50%
Chromium		1.50%		1.50%

The Ni-hard type of alloy cast iron attains Brinnell hardness values on the chilled face of from 500 to more than 750, as against 380 to 530 for corresponding grades of gray iron.[8] At the same time strength and toughness are increased greatly, so that it is a very useful material for resistance to wear and abrasion. With maximum chilled face hardness the gray iron back of the chill is too hard for ordinary machining so that if the latter be necessary, a lower alloy must be used with some sacrifice of chill hardness. Even with hardness of above 500 Brinnell, the alloy can be machined with carboloy tools.

Ni-Hard cement rolls have lasted 4000 hours, as against 600 to 700 hours for plain chilled iron, and coal pulverizer arms have ground 2400 to 2900 tons of coal as against 400 to 600 tons for the plain iron. It is more resistant to wet abrasion than is high manganese steel and it is used in preference to the latter in sand and sludge pumps in which the fully alloyed, chilled iron has given four to six months service as against four to six weeks for the manganese steel. Such pumps in the hard iron can handle pebbles up to egg size without difficulty. There are certain places in refinery operation where this material would be useful, for example in pumps handling clay, Fuller's earth suspensions, gritty oil, such as sludge-coke mixtures, or gritty water.

What has proven in the past three years to be one of the most useful alloys for refinery equipment is a cast iron containing 14 per cent of nickel, 6 per cent of copper and 1.5 per cent or more of chromium. This alloy, known as Ni-Resist, had its first commercial use in the oil industry. This was about four years ago when it was tried out as valve trim in a Texas refinery. Since then it has been applied in large tonnage to a great many applications in refineries throughout the country.

Ni-Resist is an austenitic cast iron possessing many interesting properties. Castings of it are tough, dense, pressure-tight and resistant to wear and to a great many corrosive conditions prevalent in refinery operations. In the "as cast" condition, it has better wear-resistance than ordinary gray iron. The alloy is also highly resistant to scaling, warpage and growth at temperatures up to 1500° F. Its expansion coefficient is about the same as that of the bronzes or about 50 per cent greater than that of ordinary cast iron, which must be taken

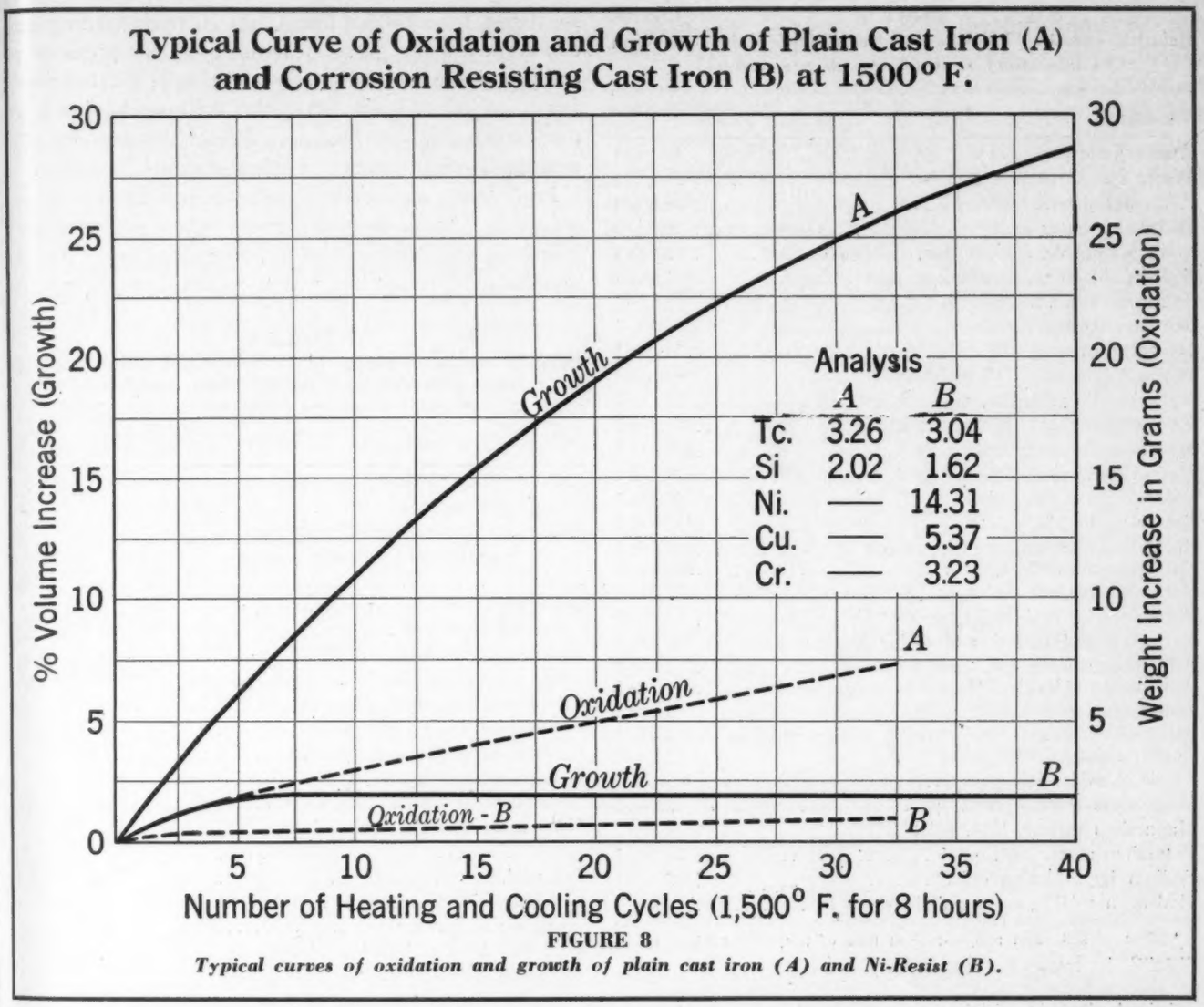


FIGURE 8

Typical curves of oxidation and growth of plain cast iron (A) and Ni-Resist (B).

into account in designing some equipment for high temperature service. Where this becomes a serious drawback, desired expansion characteristics can usually be obtained in other highly alloyed nickel cast irons which possess substantially the same order of corrosion resistance and thermal stability as Ni-Resist.

The electrical resistivity of Ni-Resist is relatively high and it is also non-magnetic. Advantage is taken of these properties in certain special cases.

Foundry practice is quite similar to that for gray iron. The same patterns and more or less the same melting practice are employed. Well equipped foundries throughout the country are producing Ni-Resist castings regularly in sizes from a few ounces up to several tons per casting. With chromium contents in the lower end of the range the alloy can be machined as readily as ordinary cast iron, but as it approaches a Brinnell hardness of 180, as the chromium content is increased to secure higher thermal stability or greater wear resistance, machining becomes more difficult. With regard to high hardness for wear resistance Brinell hardness values of 350 to 400 can be obtained by the use of chills.

Ni-Resist can be welded rather easily for a cast iron, by either the arc or oxyacetylene methods. Welds are soft and machinable and without hard ridges.

The relative corrosion rates of Ni-Resist and other materials in sulfuric acid solutions are shown in Figure 6. In this figure Ni-Resist is represented by the curve labeled "Causul Metal" which is a Ni-Resist type alloy produced by The Lunkenheimer Company. Tables 7 and 8 are further illustrative of the resistance of Ni-Resist to refinery fluids. The data given have been compiled from practical tests in operating equipment at a number of refineries. From these data it is evident that Ni-Resist is a much more useful material than ordinary cast iron under acid, salt water and sulfidizing conditions. It is likewise superior to ordinary cast iron for caustic conditions.

Large amounts of Ni-Resist have been used as renewal valve trim in all kinds of service and valve manufacturers now furnish Ni-Resist valves, frequently with other metals such as Monel metal for stems, discs and seats. The valves, and also fittings and pipe, are used in acid, acid sludge, oil, and caustic lines. There are many notable examples of good performance under severe service conditions. In one case Ni-Resist pipe has been handling acid sludge for over a year and the

TABLE 7

Relative corosion losses of Ni-Resist and plaint cast iron in laboratory tests (from various sources)

Conditions	Ratio Cast Iron Rate: Ni-Resist (Ni-Resist Rate = 1)
Atmospheric exposure for 1½ years	10 to 1
Water spray, pieces suspended vertically	31.5 to 1
Aerated tapwater—agitated	8.6 to 1
Bad boiler water at 95° C. (203° F.), CO_2 saturated	6.0 to 1
Sodium chloride, 3% solution, agitated, aerated	3.8 to 1
Sodium chloride, 3% solution, quiet	1.6 to 1
Salt spray test	2.9 to 1
Seawater, quiet	5.0 to 1
Hydrochloric acid, 1%, quiet	31.0 to 1
Hydrochloric acid, 5%, quiet	62.0 to 1
Hydrochloric acid, 5%, agitated, aerated	52.6 to 1
Hydrochloric acid, 10%, agitated, aerated	49.2 to 1
Hydrochloric acid, 20%, quiet	180.3 to 1
Hydrochloric acid, 20%, agitated, aerated	30.0 to 1
Sulfuric acid, 1%, quiet	62.2 to 1
Sulfuric acid, 5%, quiet	185.0 to 1
Sulfuric acid, 5%, agitated, aerated	85.9 to 1
Sulfuric acid, 20%, quiet	328.0 to 1
Sulfuric acid, 10%, quiet, at 100° C. (212° F.)	195.0 to 1
Sulfuric acid, 78%, quiet, at 100° C. (212° F.)	2.0 to 1
Sulfurous acid (solution of sulfur dioxide) quiet	42.9 to 1
Aluminum sulfate, 5%, quiet	4.8 to 1
Ammonium chloride, 5%, quiet	3.3 to 1
Ammonium sulfate, 10%, quiet	3.5 to 1
Ammonium sulfate, 10%, plus 5% sulfuric acid, quiet	384.0 to 1
Copper chloride, 10%, quiet	5.8 to 1
Ferric chloride, 5%, quiet	1.5 to 1
Magnesium chloride, 10%, quiet	2.4 to 1
Magnesium sulfate, 10%, quiet	4.5 to 1
Potassium alum, 10%, quiet	24.0 to 1
Sodium hypochlorite, quiet	3.1 to 1
Hydrogen sulfide, saturated, 160-180° F.	4.5 to 1

*All at normal room temperature at time of test, except where otherwise noted.

original piece is still in use. In another case a line of three-inch extra heavy wall pipe had lost only a quarter of its wall thickness after three years carrying 30 to 40° Baume sulfuric acid at a temperature of 135 to 175° F. Another line of Ni-Resist at the same refinery carried 98° Baume sulfuric acid, at 180° F.

Condenser corrosion is a troublesome matter in many refineries, especially in the top sections where temperatures are high and the vapors begin to be converted into liquid. From some of the data of Table 8 it is evident that Ni-Resist sections, at least at the critical points would be an improvement over ordinary cast iron.

Pump parts such as liners, plungers, valves, valve seats, impellers, and casings are made of Ni-Resist for oil, acid, acid-sludge, and caustic service. Completely assembled liquid ends have been made of it in some cases. A great deal of it is used by pump manufacturers for liners in hot oil pumps and many refineries have replaced plain iron liners with it. An eastern refiner solved a problem of hydrochloric acid corrosion in a reflux pump by using a Ni-Resist liner.

Compressors are also offering problems, especially on still gases with high contents of hydrogen sulfide. For such service the problem has been solved by using Ni-Resist for cylinder liners and all parts coming into contact with the gas. A number of compressors so equipped have been in service in a Middle West refinery for a period of over two years without having been torn down for overhauling. Diesel engines are also equipped with a number of other parts of Ni-Resist.

Look boxes and headers are often subjected to severe corrosion. In an eastern refinery where ordinary gray iron look box castings had to be replaced every 9 to 12 months, a Ni-Resist box was tried out some three years

TABLE 8

Relative corrosion losses in Ni-Resist and other materials from practical tests in operating equipment.

Conditions	Ratio Other Materials: Ni-Resist (Ni-Resist = 1) Steel	Bronze	Plain Cast Iron
Light naphtha rundown line (slightly acid with acetic)	4.8		2.4
Heavy naphtha rundown line, coking still, moisture and sulfuric acid present	46.1		19.7
Distillate from Crane-Upton crude, wet, 94 days test	1.5		2.0
Vapor lines at stills, 150-250 days test	20.0	8.0	
Crude distillate, with water tapped out			1.6
Condensate from crude distillation		1.7 (brass)	
Condensate from oil distillation		4.4 (brass)	
Condensate from rerun acid treated and neutralized naphtha, 130° F.			16.3
Condensate, straight run naphtha, 130°F.			5.7
Oil, acid, in still at 360° F.		30.4	
Cracking still vapor space, H_2S and organic sulfur present	10.0		3.3
Gas, wet, H S and hydrocarbons			4.0
Rerun still, acid treated and neutralized cracked naphtha, steam distilled at 300-320° F.; So_2 and H_2S present—			
In naphtha	34.5	9.9	10.0
In vapor	16.7	8.6	5.3
Acid sludge	87.5		32.5
Distillate water separated at 100-200° F. from coastal crude topping stills		220.0	67.0
Ditto, Crane-Upton crude		1.4	2.0
Water, caustic treated, settled from Panhandle and Crane-Upton distillate			6.6
Water, at 105° F., trapped from kerosene distillate		4.4	5.5
Ditto, from corrosive crude distillate			7.6
Ditto, from Coastal (acid) distillate		1.4	4.1
Water from distillate of oil, H_2SO_4 and CO_2 present			14.6
Cooling water (organic acids) from sweater pans			3.6
Harbor water, at pump intake, salty and slightly acid			3.1
Ditto, in condenser box, at 120-170° F.			2.1
Ditto, less salty and more acid, at 120-170° F.		2.7	3.9
Water, cooling, turbulent and slightly acid			2.1
Water, condenser, brackish and acid			7.3
Water in trap, acidified			4.7
Water in trap, coastal stills	3.9		14.5
Tank water, caustic neutralized Crane-Upton distillate	3.46		15.5

ago. It is still in service and since that time all its neighbors have been replaced by Ni-Resist boxes.

Shell and tube condensers and heat exchangers are logical applications for Ni-Resist castings wherever conditions of service are severe for ordinary cast iron.

Acid mixers of Ni-Resist are being used in the Middle West with considerable success.

Bubble caps and trays are logical applications. Caps have been on trial in a number of refineries. In one case plain cast iron caps lost four times as much weight as Ni-Resist in the bottom three-quarters of the tower and twice as much in top quarter in the first six months of test. Moreover the plain iron caps were pitted and a number of them were broken in cleaning, whereas the Ni-Resist caps were not pitted and none were broken.

There are applications around stills where the stability of Ni-Resist at high temperatures would be useful. A Canadian refinery, starting from a test installation, now has 11 flue dampers of this alloy in cracking stills. It is a logical material for still tube supports also, not for the hottest sections where only the specially developed heat resisting alloys will serve the purpose adequately, but for intermediate positions where the metal temperatures would range from say 1100 to 1500° F. and where the low alloy irons are not good enough.

Data quoted and applications cited have been gathered from too many sources to permit specific recognition in all cases. However, the indebtedness of the author is gratefully acknowledged. Much of the information given has been drawn from technical bulletins of The International Nickel Company, the most pertinent of which are listed as additions to the appended bibliography.

BIBLIOGRAPHY

[1]Beyer, A. H.—"Report of Comparative Physical Tests Made Upon Threaded and Unthreaded Bolt Stock Material," Columbia University, Department Civil Eng. Test Labs., Report 2225 (1931.)

[2]The Mond Nickel Co., Ltd.—"Handbook on Nickel-Copper Alloy Condenser Tubes."

[3]Clark, C. L. and White, A. E.—"Properties of Non-ferrous Alloys at Elevated Temperatures," Advance paper No. 12, A. S. M. E. (1930.)

[4]McAdam, D. J., Jr., Trans. A. S. S. T., 7, pp 598-9 (1925.)

[5]National Metals Handbook, Fig. 13, p. 47 (1930.)

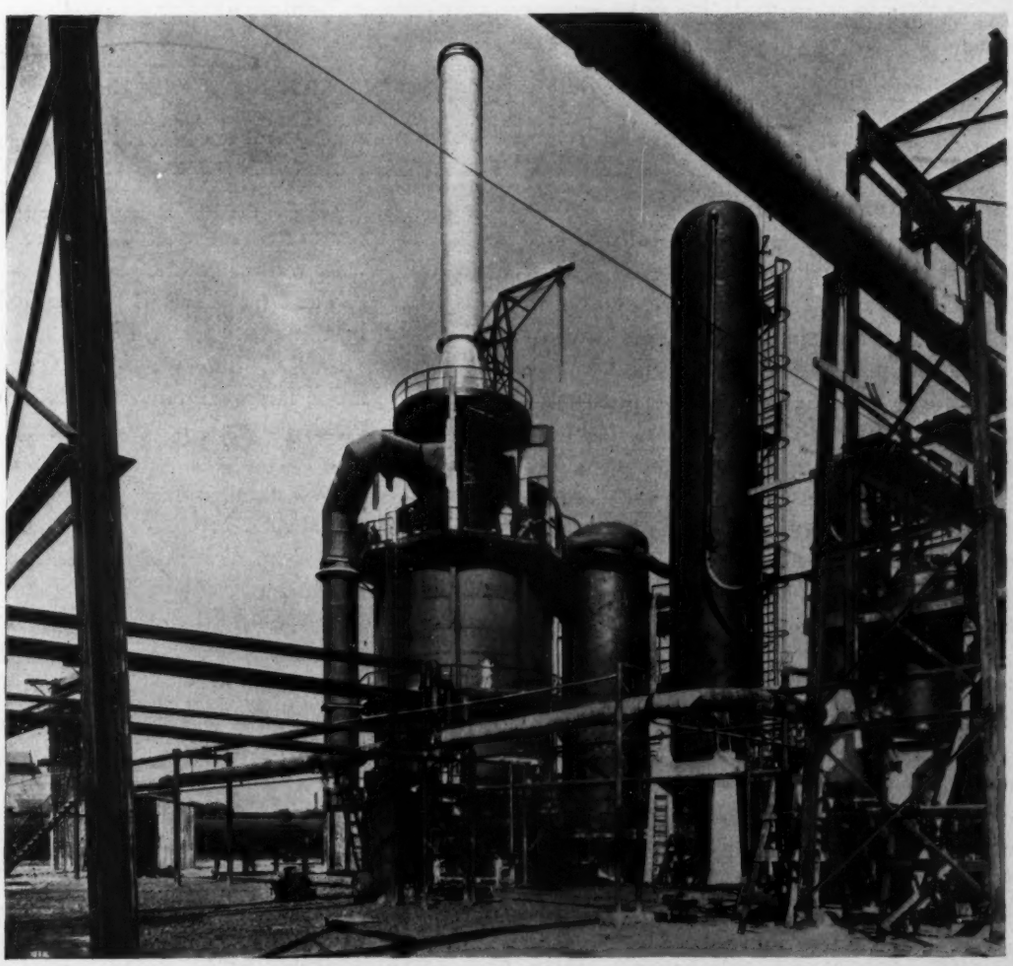
[6]Malcolm, V. T.—"Nickel Chromium Steels for High Temperature Service," International Nickel Co., Bulletin No. 15.

[7]French, H. J. and Homerberg, V. O.— "The Role of Nickel in Nitriding Steels," Trans. A. S. S. T. 20, pp. 481-504 (1932.)

[8]Vanick, J. S.—"An Improved Nickel-Chromium Hardened Chilled Iron," Contribution No. 33, A. I. M. M. E. (1933.)

[9]Technical Bulletins of The International Nickel Co.

No. 8A—"Nickel Alloy Steel Castings."
No. 9—"Physical Properties of Nickel and Nickel-Chromium Steels."
No. 12—"Alloy Steel for Boiler Construction."
No. 15—"Nickel Chromium Steels for High Temperature Service—Valves and Bolts."
No. 17—"Nickel Alloy Steel Forgings."
No. 202—"Improving Gray Cast Iron with Nickel."
No. 208—"Ni-Resist—A Corrosion and Heat Resistant Nickel-Copper-Chromium Cast Iron."
"Nickel Cast Iron Data—Guide to the Selection of Engineering Specifications."
"The Petroleum Industry Applies Ni-Resist."
No. T-1—"Monel Metal Bolts—Outline of Properties."
No. T-3—"Sulphuric Acid vs. Metals."
No. T-4—"Methods for the Fabrication of Nickel-clad Steel Plate."
No. T-5—"Engineering Properties of Monel Metal."



A de Florez type vertical up-draft heater in cracking service in an eastern refinery. Capacity 1,000 barrels per day, cracking gas oil or reforming naphtha. Erected by M. W. Kellogg Company.

PART 2

Meeting Some of the Problems of the Pressure Vessel User

T. McL. JASPER, O. E. ANDRUS, L. J. LARSON
Research and Development Engineers, A. O. Smith Corporation

THE accompanying discussion constitutes Part Two of a series on pressure vessels and meeting the problems of their users. The question of pressure vessel design is of paramount importance. The chief concern of the user is the effect of design on economy and safety in the processing of his product. Since the pressure vessel is the nucleus of the greatest hazard, the safe design of this part of the unit should be given careful consideration.

The oil industry furnishes a service test which is searching in its demands on vessels. Improvements in designs and in fabrication methods has increased the safety and usefulness of vessels and his resulted in considerable economies in the production of gasoline and other products.

METALLURGICAL SYMPOSIUM

ECONOMIC design, from the standpoint of conserving materials, requires that all parts of the structure have equal strength, and this principle should be followed as far as commercial practicability will allow. The essential factors deal with correct shape and the reinforcement of all openings. Added to these are the questions of the appropriate safety factor to allow for contingencies and, where corrosion prevails in service, the proper allowance in added thickness or corrosion resistant liners to care for reasonable life of equipment.

The spherical container is the ideal shape so far as the most economical use of material is concerned, but in large sizes such containers are clumsy to transport, house, and service, and costly to fabricate for high pressure and temperature service. Cylindrical vessels, however, have dominated the field of pressure vessel service, and this has grown around the fact that they are much more convenient to use and fabricate.

In cylindrical vessels with welded joints having a strength and ductility comparable to those of the steel joined, it is essential to use heads of proper shape and adequate reinforcement of openings if the most economical use of the material or the greatest strength for a given weight is to be obtained. In riveted vessels, the joints leak at such relatively low pressures that it is somewhat unimportant to consider the shape of heads or reinforcement of openings. The dished head commonly used in riveted vessels is amply strong to bring the vessel above the leak point without failure, and no important troubles are encountered because of unreinforced openings. The application of welding to proper design features has, therefore, had a marked effect in improving the safety of vessel operation.

To illustrate this point, two sets of curves are shown which were obtained from tests on a six-foot diameter cylindrical vessel with a wall thickness of two inches and a length of between 40 and 50 feet. The vessel was prepared with both reinforced and unreinforced manways, and had a correctly designed elliptical head at one end and a dished head at the other. Strain measurements were made at a large number of locations on the vessel, and the curves selected in Figures 9 and 10 were from the most highly stressed portions in any particular location in the vessel. These bring out very clearly the value of the design features possible with welded joints.

The first curve in Figure 9 shows the typical strains in the cylinder wall at a location removed from any openings. The pressure at which the yielding of the metal is shown corresponds to that computed from the yield strength of the steel as obtained independently in a tensile test made on bars cut from the plate before it was made into the vessel. The second curve shows the strains in the cylinder wall adjacent to an unreinforced opening and indicate that the yield strength was reached at this location at about 60 per cent of the pressure required to produce yielding at the location represented by the first curve. The third curve shows strains at the weakest section in the dished head. The yielding occurred at a pressure of about 80 per cent of that required to cause yielding at the location represented by the first curve. Since the material at the locations represented by the three curves in Figure 9 had practically identical yield strength values, the difference in pressure required to produce yielding indicates the degree of stress intensification at each location.

When the test was carried to destruction, the vessel failed in the unreinforced manway. This manway was

FIGURE 11

Vessel of layer construction which burst on testing at 20,200 pounds per square inch hydraulic pressure.

then repaired and reinforced after which the vessel was again tested to failure. This time it failed in the dished head. The pressures at which these failures occurred have a relation to the calculated ultimate pressure of the cylinder almost identical with the relations shown in Figure 9.

The curves in Figure 10 were made from strain measurements obtained adjacent to a properly reinforced manway and a properly proportioned elliptical head and were obtained at the same time as those represented in Figure 9.

Other tests on vessels with reinforced openings and elliptical heads have confirmed the tests described above, and adequately indicate the possibilities of obtaining, through the use of welding and correct shape, the full strength of the materials used. Such tests indicate the low factors of safety of vessels which industry has been using.

Additional tests on full size vessels have been made to study the action of conical and flat heads and to check design formula for very thick wall vessels. Tests of this kind show conclusively the value of the theories used in pressure vessel design, as well as prove the ability of the fabrication methods to produce vessels of a desired degree of safety.

THICK WALL VESSELS

The use of high pressure has resulted in demands for very thick wall vessels. It is well known that the properties of a rolled plate depend to a considerable extent on the amount of rolling or kneading it receives, and hence, thick plates are relatively inferior to thin plates of the same type of steel. The fabrication of a vessel from thick plates results in a very stiff structure which cannot readily adjust itself to correct shape nor to change of shape under pressure, and such a vessel bursts with an explosive or shattering effect when tested to destruction. This difficulty has been overcome by using a construction consisting of a number of thin plates fitted tightly together in a series of concentric rings. This type of construction with proper reinforcement of openings and shape of heads has been tested to destruction with the most satisfactory results. These tests have been repeated to demonstrate the reliability of such a vessel. This construction also lends itself to

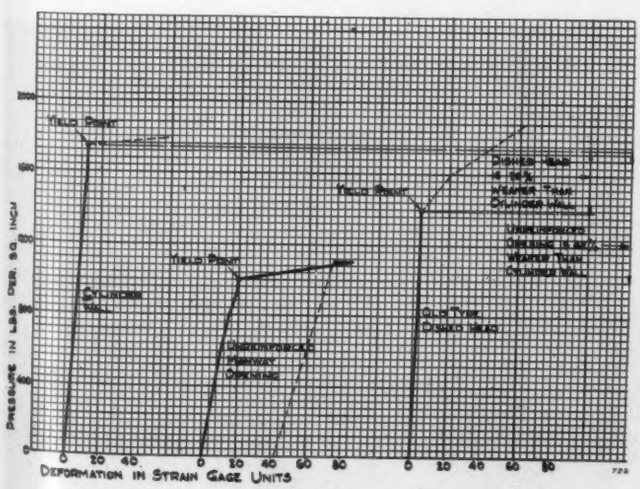

Yield Point
Yield Point
Yield Point
Cylinder Wall
Unreinforced Manway Opening
Solid Type Dished Head
Pressure in Lbs. per Sq. Inch
0 20 40 0 20 40 60 80 0 20 40 60 80
Deformation in Strain Gage Units

FIGURE 9

Relation between pressure and deformation for poorly designed large test vessel. Yield point in each curve occurred at some stress in steel.

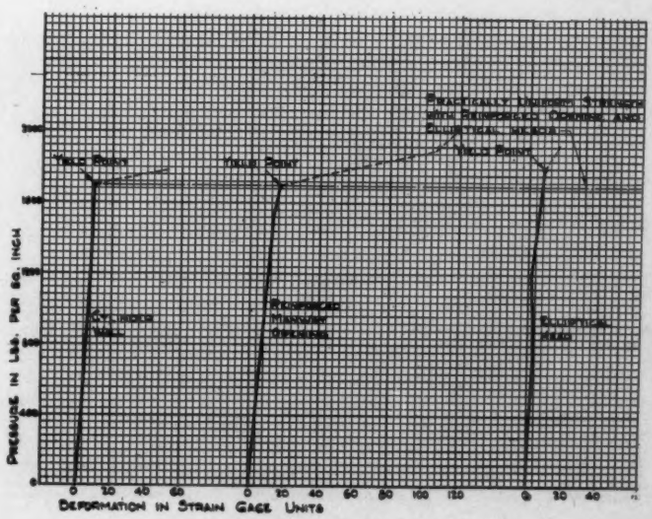

Yield Point
Yield Point
Yield Point
Cylinder Wall
Reinforced Manway Opening
Elliptical Head
Pressure in Lbs. per Sq. Inch
0 20 40 60 0 20 40 60 80 100 120 0 20 40
Deformation in Strain Gage Units

FIGURE 10

Relation between pressure and deformation for properly designed large test vessel.

FIGURE 12

Ten foot cylindrical vessel with spot welded corrosion resistant liner.

making the inner shell of alloy or corrosion resistant steel, while the outer layers may be made of the most economical load carrying steel.

Figure 11 shows a vessel made up of 3-27/32 inches of steel in layers, with an inside diameter of 19¼ inches. When tested to destruction, the hydraulic pressure at failure was 20,200 pounds per square inch, a value which is the highest ever obtained with the dimensions and materials used. A companion vessel of the same dimensions failed at 19,100 pounds per square inch. Vessels of this type develop the full strength of the steel and burst by tearing the plates without any shattering such as is typical when thick wall vessels are tested to failure. A few of these vessels are in service and are working in a very satisfactory manner.

In comparison to the above, thick wall vessels of solid construction have been tested to destruction and these have invariably failed at lower pressures, for a given thickness of wall and diameter, than is the case with the layer construction. The strength values of a thick wall vessel will be at least 15 per cent lower than that of a layer vessel when made of the same kind of steel. Part of the advantage in layer vessels is due to the greater strength of the steel when rolled into thin sections and part of it is due to the ability of this construction to accommodate itself more readily to the most appropriate shape to resist the pressure.

The engineer is often called upon to design vessels in which a consideration of corrosion is of importance. The use of solid stainless steel vessels for high pressures and/or temperatures is uneconomical. The seriousness of corrosion relative to process economy and safety of operation has led to the development of a metallic lining of corrosion resistant metal. This construction employs thin sheets of corrosion resistant alloy, spotwelded at frequent intervals to the carbon steel

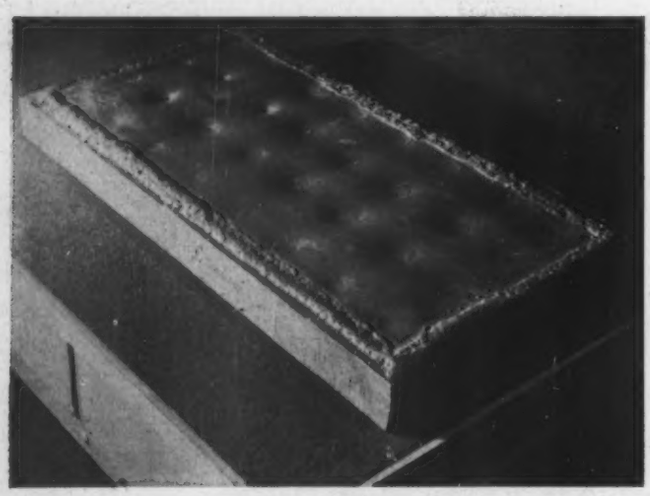


FIGURE 13

Lined plate after 1,000 pounds hydraulic pressure had been applied between liner and plate.

FIGURE 14

Alloy buttons before and after corrosion test.

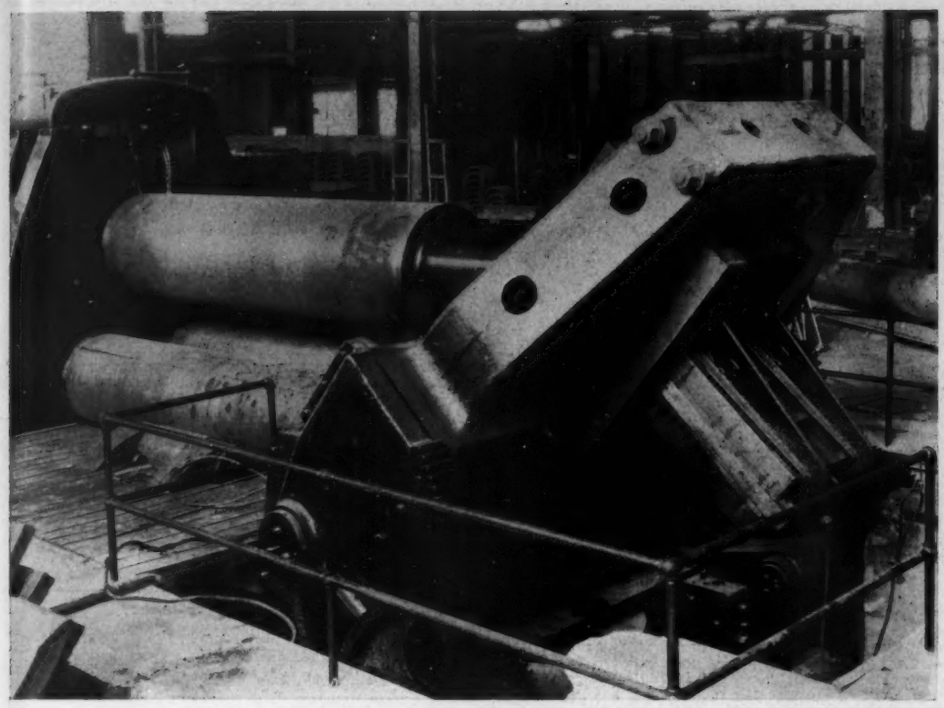


FIGURE 15

A modern large 8,000,000 pound roll.

vessel in such a manner as to make the lining an integral part of the vessel wall including heads, manways, nozzles, etc. Figure 12 shows such a liner applied to a commercial vessel. Several such vessels are in satisfactory service. This type of construction insures permanency of protection against the chemical and physical forces encountered. The thickness of alloy is uniform throughout, and is sufficient to afford many years of protection under the most severe conditions. The method of bonding the liner to the shell insures physical stability against temperature and pressure changes encountered in the cycle of operation.

The test block in Figure 13 indicates the mechanical strength of the bond between the liner and the plate. It was prepared by spotwelding the liner to the plate at three-inch intervals, which is from two to three times the customary spacing of spots used in commercial vessels, and the edges of the liner were sealed by arcwelding. Even with the large spacing used in the test, a pressure of 1000 pounds per square inch applied between the liner and the plate did not break the bonds, as may be seen from the photograph.

The adequacy of the liner to protect the load carrying steel wall is indicated by its service record to date. No vessel has as yet shown any corrosion under a metallic liner. Liners in nozzles and manway necks which have been in service more than five years show no apparent reduction in thickness even when the vessels

FIGURE 16

Introduction of a 10-foot diameter vessel into the electric furnace for removal of fabrication strains.

FIGURE 18
A large vessel with 31 manway openings.

have been used on highly corrosive oils. A number of completely and partially lined vessels have been built for the oil cracking industry and have given satisfactory service to date. Much has been learned in the manufacture of these vessels; however, the most important consideration is that of the alloy composition of the liner. For instance, an experimental liner of 18 chrome 8 nickel steel with about .20 carbon has slowly developed intercrystalline hairline cracks after several years of service. A lower carbon alloy of similar composition has been found to be far more resistant to intercrystalline corrosion. Steel manufacturers now market a steel of this type which is claimed to be entirely free from this objection. The more recently lined vessels for the oil industry were made with an 18 chrome alloy which is not subject to this form of slow deterioration under oil cracking service conditions. In all cases, the alloy should be chosen to meet the particular requirements demanded in service.

The possibility of liner design relative to processing economy and safety is of considerable interest to industries using pressure equipment subject to chemical deterioration. In the lined vessel, the original safety is preserved throughout the structure since corrosion of the load carrying steel is entirely prevented. The practice of drilling inspection holes, which weaken the vessel, is unnecessary, since the presence of the liner is proof of the constancy of wall thickness. Economies result from minimizing the period of shutdown, the maintenance and inspection cost, and the loss of working volume due to the thickness of the protective coating sometimes used. Yield, throughput, and operating flexibility are not lessened since corrosion does not occur, and, therefore, the operating pressure and temperature never require dropping for reasons of safety.

A construction for vessels built without metallic liners, which has reduced the cost of inspection and has increased the safety of operation, consists in the use of non-corrosive alloy buttons fastened to the inner surface of the vessel at convenient locations for the purpose of determining the amount of corrosion and the constancy of shape of the vessel. As corrosion progresses, the buttons stand out in relief, thus enabling the inspector, with the aid of templates, straightedge, and scale, to determine the corrosion loss and any distortion of the vessel.

Figure 14 shows two test blocks prepared by welding alloy buttons in place. The upper block shows the buttons before corrosion, and the lower block shows them after corrosion has taken place. This test was made in

nitric acid to accelerate corrosion. In oil vessels coking would probably entirely prevent the corrosion of the carbon steel directly beneath the button.

The alloy button has several advantages. Most important is the elimination of inspection holes. These holes cause stress concentration which has been known to cause cracking of the surrounding steel. The direct cost of inspection is appreciably reduced, but of greater concern is the saving in reduced shutdown time. If a sufficient number of alloy buttons is used, the adequacy of the inspection is greatly increased.

FABRICATION

Equally as important as is design and the selection of suitable materials is the fabrication of the vessel. In the fabrication of pressure vessels it is most important that the materials be thoroughly inspected and tested, that suitable and adequate equipment be available, that proper methods of fabrication be employed, and that the personnel be carefully selected and trained. The capacity of a plant for vessel fabrication depends primarily on the kind and size of equipment. The quality of the product depends particularly on methods of fabrication, personnel, and inspection.

Large electric furnaces for heating thick plates before they are rolled into cylinders, rolls capable of rolling five-inch thickness of plate cold and a greater thickness hot, electric and oil fired furnaces for stress relieving the finished vessel after fabrications; these have become necessary in order that vessels of thick walls may be built satisfactorily for safety of operation.

Although thin plates of low carbon steel may be cold rolled satisfactorily into cylinders, it is essential that thick plates be formed hot in order to safeguard the user of vessels against service failure.

Some of the equipment used in the fabrication of heavy plates is shown. Figure 15 shows an 8,000,000-barrel roll and Figure 16 shows the introduction of a 10-foot diameter vessel into the large electric furnace for final treatment in the removal of fabrication strains. This furnace is 68 feet long, 12 feet wide, and 15 feet high. Included are two figures of pressure vessels which have been built. Figure 17 shows one of the largest vessels in service, and Figure 18 shows a vessel with a large number of manway openings.

The problems of the pressure vessel user are met providing that appropriate designs, satisfactory materials, and good fabricating methods are combined in the finished vessel. The check of these items is accomplished by adequate inspection of each part of the process. This inspection involves tests on materials and appropriate supervision of the fabrication procedure in the plant. The final inspection, including X-Ray if required, and test of the completed vessel has a place in furnishing added assurance of satisfactory performance. The best assurance, however, lies in the use of a proven method of fabrication and the integrity of the manufacturer.

SERVICE RECORD

Vessels of the type shown in Figure 17 and 18 have been in high pressure and/or high temperature service since 1925. The number of such vessels in the oil industry which have been fabricated by welding is somewhere between two and three thousand. The severity of this service, coupled with the hazard encountered, requires strict adherence to a reliable method of production.

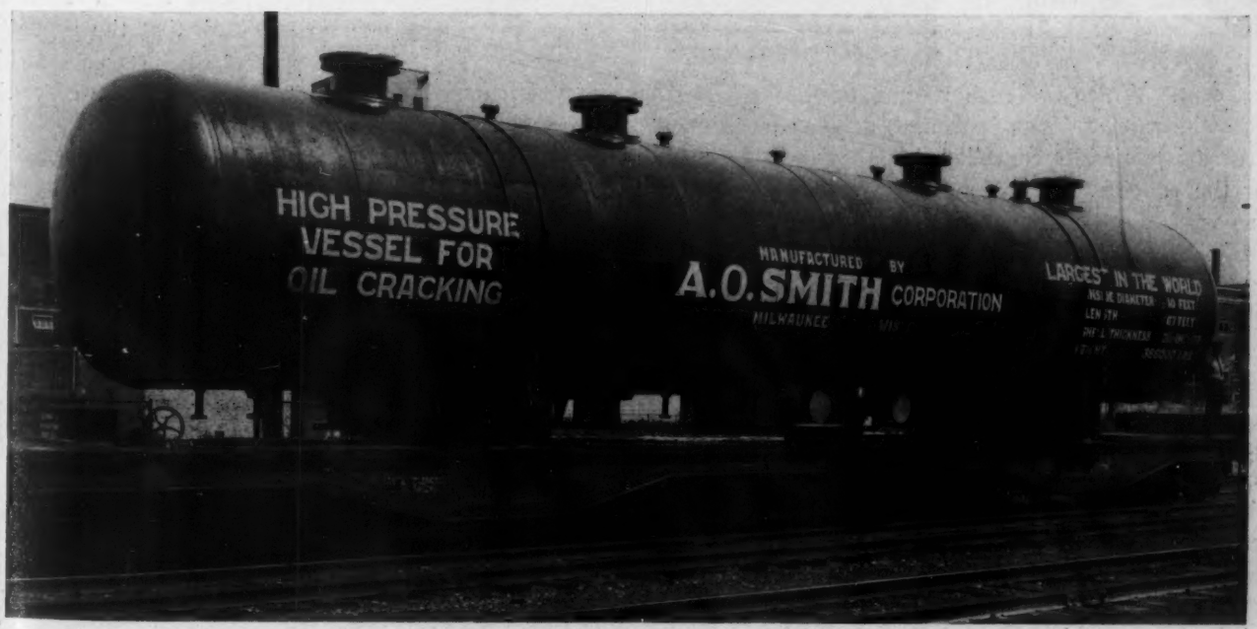


FIGURE 17
One of the largest vessels now in service, weighing 400,000 pounds.

Characteristics of Steel *at*... Elevated Temperatures

FRANCIS B. FOLEY
Superintendent of Research, The Midvale Company

IN a discussion of steels for use under the conditions of heat and of corrosive attack such as are met within oil refineries and the chemical industry the size of the particular part, its method of manufacture, whether a casting, a large or small forging, or a rolled or drawn product, the type of corrosion to be withstood, the temperature of exposure and the nature of the gaseous atmosphere, all have to be given consideration. Although alloy steels for the purposes under consideration may overlap in their applications they may broadly be classified into corrosion-resisting and heat-resisting steels, and these may again be broadly classified into high alloy and low alloy steels—the former for more severe conditions of corrosion or temperature application and the latter for the less severe conditions.

METALLURGICAL SYMPOSIUM

PLAIN carbon steels are useful at temperatures up to say 850° F., low alloy pearlitic steel up to 1100° F., and the high alloy steels at the higher temperatures. These temperature ranges are dictated by the nature of the three types of metals. The use of carbon steel is limited to low temperatures because of its low physical strength at temperature and its low resistance to oxidation. The addition of low percentages of alloying elements, for example, Mn, Cr, Mo and W, increases the strength of pearlitic steels at temperature and reduces the rate of scaling, thus increasing the range of their usefulness. Figure 1 shows the strength of C.28 per cent steel under quick tensile testing as compared with a steel of C.21 per cent, Cr4.5 per cent, Mo.60 per cent. While these short-time tensile test results show the rate of loss of strength at elevated temperatures it is generally conceded that they are of use only for the roughest purposes of design and possibly for purposes of comparison. Even the most precise determinations of the elastic limit so far employed have not furnished figures which it has been possible to correlate with the deformation to be expected over long periods under load at elevated temperatures. What a steadily growing mass of data will ultimately disclose of a nature to make short-time test figures more useful than they appear to be at present remains to be seen. Fort the present, the tedious process of "creep testing," whereby the steel is actually heated to the desired temperature, maintained at temperature under constant load for long periods during which the deformation, if any, is observed from day to day, is productive of data useful for accurate design work for elevated temperature service. Even in the case of creep testing only the most accurately controlled testing conditions are capable of giving accurate and dependable values. Variations in the initial conditions of a given alloy, variations in accuracy of temperature control and of measurements of deformation all lead to inconsistencies in results. Figure 2 shows a battery of creep testing units in use in the laboratories of the Midvale Company and Figure 3 the method of direct reading of deformation.

It has to be borne in mind that the mere subjection of pearlitic steels to elevated temperatures is of the nature of heat treatment, but heat treatment of a type about which we are not generally well informed. Steel will tend to attain structural stability for any temperature to which it is exposed and it therefore follows that the properties determined on a steel which is not structurally stable at the temperature of testing are not dependable for application to structures which are maintained at that temperature for periods considerably longer than those used in the tests. To take, as an extreme example, the creep properties of an undrawn quenched steel as a basis for design for equipment which is to have a life of many years at elevated temperatures would be ridiculous. Bailey estimates that a normalized and annealed steel would undergo spheroidization of its carbide over a period more than 55 years at 800° F. In equipment designed for a life of say only five years at this temperature the effect of structural change as sluggish as this would possibly not be of great consequence. If the same degree of spheroidization is attained in half a year at say 1000°F. it would not be good judgment to base design on creep properties determined at this temperature in 1000 hours, unless the specimens had been given a stabilizing treatment before hand.

From what has been said it is readily grasped that,

prior to determining creep values at low temperatures, specimens should be exposed to higher temperatures at which structural stability for the lower temperatures will be attained in a reasonable length of time. Having done this and having used the known necessary precautions to be exercised in conducting creep tests there should be relatively little variation in the results obtained with the same steel tested by various operators.

SCALING

Scaling takes place with noticeable rapidity at temperatures in excess of incandescence. In some installations considerable scaling can be tolerated—in others it must be held to a minimum. Scaling causes a reduction of the section and thus reduces strength, and under load it is possible that oxidation actually reduces the strength of a material perhaps as playing water on a specimen during fatigue testing gives rise to the familiar "corrosion fatigue." Little, if anything, is known of this latter phenomenon. The results obtained in creep testing of scaling steels at scaling temperatures are probably lower than would be expected in large size equipment, for the reason that the proportion of surface to mass in a small round bar of one-fifth of a square inch area is much greater than in larger equipment.

The question of scaling introduces the higher alloy steels, many of which are useful under specific conditions for corrosion resistance at atmospheric temperatures. Here the low alloy steels blend into the high alloy steels. Much of the usefulness of the extensively

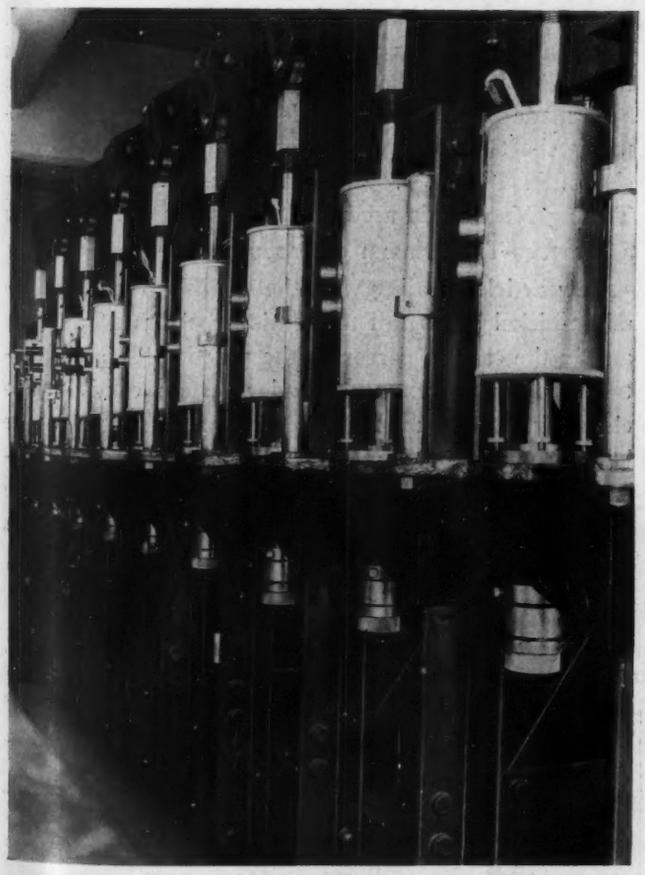


FIGURE 2
Battery of Midvale creep testing units.

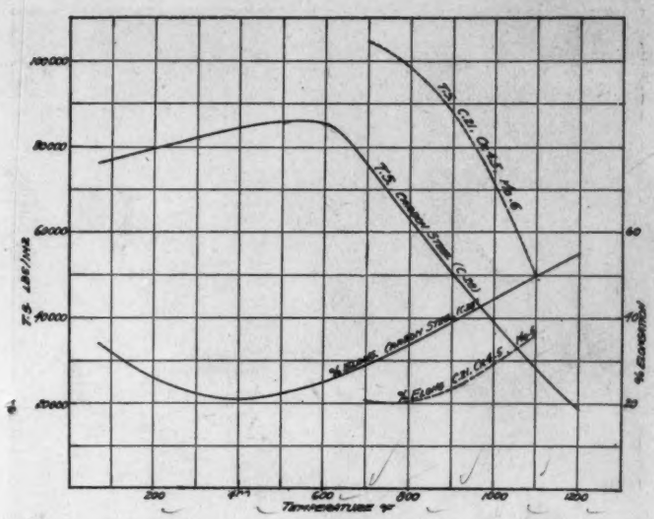


FIGURE 1
Short-time tensile properties of plain Carbon .28 and C .21, Cr 4.5, Mo .6 steels. Plain carbon steel in normalized condition and Cr-Mo steel annealed and drawn at 1200°F.

used 4 to 6 per cent chromium steels depends on its scale resisting properties. Its relatively low creep strength limits its application and it has been thought advisable to add to it say .5 per cent of molybdenum or 1 per cent of tungsten. The effect of chromium and carbon on room temperature physical properties in steel of this type has been covered rather extensively in a recent paper by Wright and Mumma, read at the 1933 annual meeting of the A.I.M.E. These steels have strong air-hardening tendencies even with carbon as low as .10 per cent and chromium 5 per cent. This tendency introduces hazards in fusion welding, since the metal in the neighborhood of the weld, having been heated to a high temperature, undergoes considerable hardening during air-cooling. The introduction of molybdenum or tungsten tends to accentuate this air-hardening.

From this low point in chromium a whole series of steels of increasing chromium content running up to 30 per cent of chromium, and even above, become available for higher temperature service. They are not noteworthy for strength at temperature, being, for the most part ferritic steels, and characterized by rapid grain growth at high temperatures, a tendency which is combatted to a large extent by the addition of small percentages of nickel. They have high resistance to organic acids at atmospheric and slightly elevated temperatures and to scaling at high temperatures.

AUSTENITIC STEELS

The strengthening and toughening of these ferritic chromium steels at normal and elevated temperatures is accomplished by additions of nickel, producing austenitic steels, the most familiar type of which is the 18 per cent chromium, 8 per cent nickel steel. In general, where the chromium exceeds the nickel, these alloys show excellent resistance to organic acids, being more resistant than the 11 to 13 per cent chromium steels in this respect. When the nickel content exceeds

FIGURE 3
Method of direct reading of elongation under load.

the chromium the resistance to organic acids is decreased and resistance to sulphuric and hydrochloric acids is increased.

Corrosion is very imperfectly understood phenomenon and becomes difficult to interpret when the corrosive medium is of a complex character. Laboratory tests, therefore, frequently prove a useless guide to service application and the method of empirical trial under actual service conditions is often the only method of indicating the type alloy for use under the specific conditions.

At quite high temperatures, say above 1600°F., the short life of laboratory furnaces and the difficulty of making observations of the amount of deformation render creep testing for the present at least impractical. Moreover, the design and condition of exposure in service do not generally demand the accuracy of data produced in creep testing and, particularly at the very high temperatures, the loads producing low creep rates would be so low as to demand even more accurate testing than at lower temperatures to give the same proportional accuracy in the results. Results from short-time tensile tests, therefore, combined with service experience is made the basis for designing for the high temperatures. Table I gives a series of chromium-nickel alloys with their short-time tensile strengths at temperatures up to 2000°F. It will be noted that the tensile strengths at 1400° are very much higher than those of low alloy steels at 1200°F.

Obviously, all installations cannot be designed using the same factor of safety, but average design factors applied to these tensile strengths give the permissable working stresses listed. It is possible that certain designs will permit higher stressing and others lower stresses, but these figures represent what might be termed average experience. Here again the necessity of accuracy in elevated temperature testing is to be emphasized. Speed of applying the load is of obvious importance, as is also the accuracy of temperature measurement. The recently adopted code of the A.S.T.M. for short-time testing at elevated temperatures requires a speed not in excess of .01-inch per minute for loading up to the yield strength and .25-inch from that point to the tensile strength. The significance of the yield strength or elastic limit at elevated temperatures is not known and has found little, if any use in practice. But, since it appears possible for laboratories to check the value with reasonable closeness, provisions have been made for its determination. The set-up for measuring short-time elevated temperature properties is shown in Figure 4. A Southwark-Emery Hydraulic Testing Machine is used and extensions are read with a Martens-Tuckermann extensometer.

Few articles dealing with the use of austenitic chromium-nickel steels fail to mention the loss of ductility and in the case of corrosion the practical decay of certain alloys upon exposure under certain conditions to elevated temperatures. It appears that almost all steels have a temperature range in which, if tested at temperature, there is found a falling off in impact resistance or ductility. In carbon steels this temperature range is

TABLE I

Elevated Temperature Tensile Strength and Approximate Design Strength of Cast Heat-Resisting Chromium-Nickel Alloy Steels.

		1400°F.		1500°F.		1600°F.		1700°F.		1800°F.		1900°F.		2000°F.	
Cr	Ni	T.S.	Des. Str.	T.S.	Des. Str.	T.S.	Des. Str.	T.S.	Des. Str.	T.S.	Des. Str.	T.S.	Des. Str.	T.S.	Des. Str.
25	10	34,800	4,580	23,000	2,705	18,250	1,880	15,900	1,360	11,850	590	.....	.....	.....	.....
25	20	35,200	4,650	27,000	3,175	20,600	2,110	15,300	1,300	11,200	560	.....	.....	.....	.....
17	35	35,500	4,670	24,300	2,860	19,000	1,960	15,200	1,300	12,050	600	8,460	275	.....	.....
20	60	33,100	4,355	24,100	2,835	18,200	1,875	14,200	1,215	11,400	570	9,600	315	8,350	200

low (Figure 1); in austenitic chromium-nickel steels it is much higher, (Figures 5 and 6).

The effect of temperature on chemical and on physical stability is shown in three ways. It has been found that the resistance of the 18-8 type of chromium-nickel alloy to corrosive attack at atmospheric temperature is seriously impaired following exposure to temperatures of from about 1100 to 1600°F. This has been attributed generally to the formation and precipitation of chromium carbide from solution at the crystal boundaries within the steel in this range of temperature. It is thought that, in the formation of the carbide, chromium is drawn from solution in the metal immediately adjacent to the carbon, thus lowering the chromium content and, consequently, the resistance to corrosion of the surrounding layers. The carbon usually precipitates at the boundaries of the crystals and the attack is found to follow the crystal boundaries. The rate of diffusion from the center of the crystal to the impoverished boundaries is slow at these temperatures, and, when the amount of chromium in the composition is but little more than sufficient to produce resistance, the amount lost from solution in forming the carbide

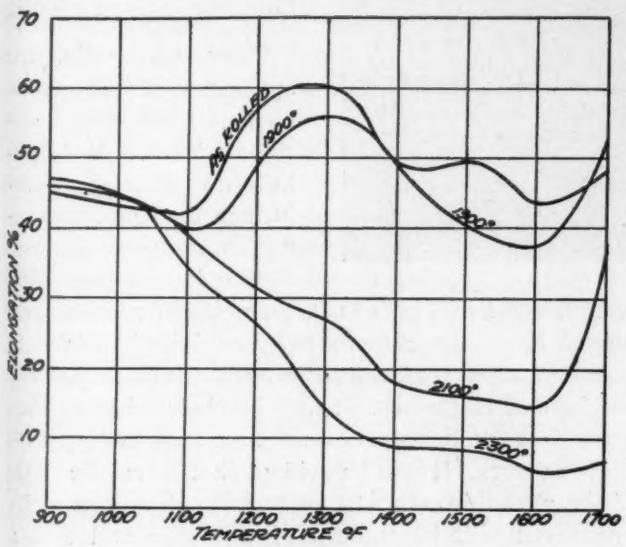


FIGURE 5

C.05, 18-8 Alloy. Elongation at elevated temperatures. Specimens quenched from temperatures shown on curves. (Newell, Trans. A.S.S.T. Vol. 19, June, 1932.)

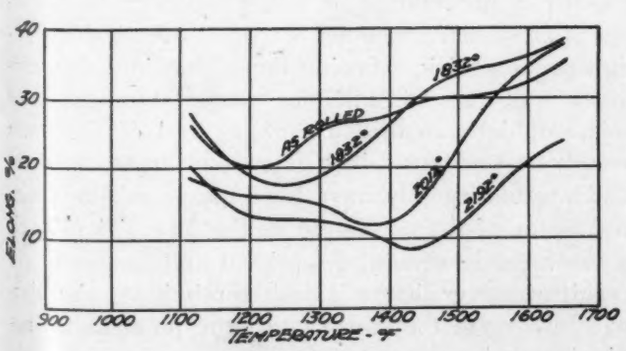


FIGURE 6

C.44, Cr 14.5, Ni 28.0, W 3.40. Elongation at elevated temperatures. Specimens quenched from temperatures shown on curves. (Handforth, Jrnl. I. & S. Inst., 1932 II).

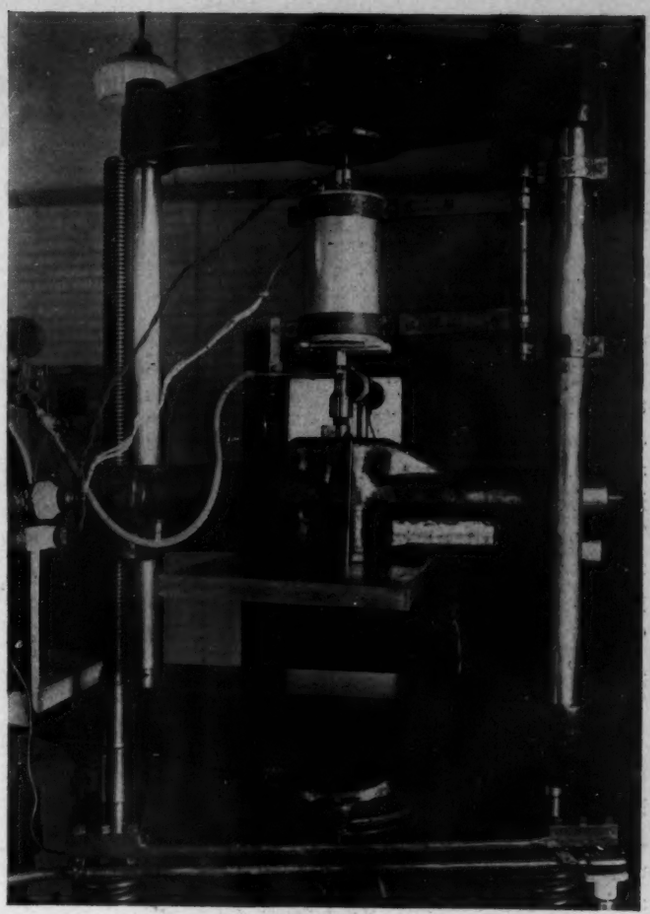


FIGURE 4

Southwark-Emery hydraulic testing machine equipped for short-time testing at elevated temperatures.

and the failure of diffusion to restore the necessary chromium to the impoverished regions seriously lowers the resistance to attack.

Two methods may be resorted to in order to overcome this difficulty. One is by adding such elements as Mo, Ti, W, etc., to the composition, and the other, generally more effective, to increase the amount of the elements chromium and nickel, already present. The elements added seem to have the effect of replacing chromium to some extent in combining with the carbon. By increasing the amount of chromium and nickel the overall resistance to attack is improved and simple treatment, in the case of a 25 per cent chromium, 20 per cent nickel alloy, suffices to prevent attack.

A second temperature effect is found in the reduced ductility on room temperature testing of alloys that have been exposed for long periods to elevated temperatures. This effect is also found to be present in low alloy steels containing, according to Bailey, nickel in excess of two per cent, and absent when over .6 per cent of molybdenum is added. In the case of equipment which is designed for and used at elevated temperatures it is the properties at temperature that are of importance, and it does not follow that low values at room temperature indicate equally low values when hot. Materials found to be susceptible to loss of some duc-

(Continued on page 197)

Safety Drilling...

Low Cost Insurance For Process Equipment

JOEL H. HIRSCH
Member of Staff, Luis de Florez Consulting Engineer

NO problem in recent years has received more serious thought from engineers and refinery operators than that of effectively safeguarding life and property against the hazard of explosions and fires which inevitably accompanies the processing of highly combustible materials at high temperatures and pressures. That considerabe progress has been made through the medium of rigid periodic safety inspection is generally conceded. Safeguarding of equipment by inspection is attended by a number of difficulties.

Corrosion in its most treacherous form, spotty corrosion, is so erratic in its occurrence that an excessive number of test holes would be required for absolute protection. Standard practice requires that these holes, which are necessarily drilled completely through the metal wall, be sufficiently large to permit insertion of a calipering device. If this procedure were carried out, the equipment would not only be so thoroughly covered with test holes as to be materially weakened, but the periods during which the unit would be shut down for inspection would be so long and so frequent as to be unfeasible.

METALLURGICAL SYMPOSIUM

THE generally accepted safety method is that of drilling a moderate number of test holes at points where corrosion is most likely to occur. The location of these inspection holes and the appraisal of dangerous conditions is, therefore, subject to the fallability of human judgment.

In February, 1931, a serious explosion in a large Mid-Continent refinery, which resulted in the loss of several lives and a vast amount of property damage, forcibly brought to the attention of Luis de Florez the imperative need for a method of safeguarding refinery equipment, which would uniformly protect the entire equipment without weakening it and without necessitating frequent and extended down periods. Accordingly, a procedure which has since come to be known as Safety Drilling was conceived by Mr. de Florez and after some trial the method was presented to the industry in the latter part of 1931.

At present this system is incorporated in cracking equipment having an aggregate daily capacity in the neighborhood of 300,000 barrels. To date specific records have been obtained of about 150 failures detected through the medium of Safety Drilling. These failures occurred in spite of rigid equipment inspection; hence, it seems reasonable to infer that in a large number of the 150 instances conditions of more or less serious consequence were averted.

It seems desirable at this time to briefly review the method of application of safety drilling and to answer, in the light of information now available, certain questions which were raised when the system was first presented to the industry.

Safety drilling consists essentially of drilling small holes in the walls of equipment, the diameter, depth, shape, and spacing of such holes being fixed by certain definite specifications, which study and experience have indicated will provide maximum protection. When corrosion or erosion occurs to thin the container wall to the predetermined lowest safe bursting limit, usually taken at about one-half the wall thickness, leakage occurring at these drilled points furnishes the necessary warning that the stipulated safety limit has been exceeded.

More specifically, the application of this method consists of drilling a series of holes, one-eighth-inch to three-sixteenth-inch in diameter, according to a regular pattern. Figure 1 shows a typical pattern for a 6⅝-inch O.D. pipe, which according to present knowledge appears to be sufficiently drilled to take care of any spots of corrosion which may occur and become dangerous. It may be observed from Figure 1 that the holes terminate in a cone having a 90 degree vertex. It will be evident that when the walls of the pipe thin, the first part of the drill hole to be uncovered will be the tip of the cone and that a very small leakage takes place at first.

It is present practice to drill the hole to a depth equal to one half the wall thickness required for the original desired factor of safety, disregarding corrosion allowance. In other words, if the pipe is five-eighths-inch thick, allowing one-eighth-inch for corrosion and one half-inch for normal strength, the hole would be so drilled that the end of the cone would be one-fourth-inch from the outer surface, which would roughly correspond to one half the original factor of safety desired in the pipe. The depth of the holes is, of course, optional and can be made to suit whatever theory is desired relative to the ultimate minimum thickness which the pipe should retain in service.

The holes are drilled with a standard drill (Figure 2) sharpened to a greater taper than for normal drilling, in order to give the proper shape to the bot-

tom of the hole. When drilled in the field, a standard electric drill is used with a stop which is adjusted to the predetermined depth. Where holes are drilled in insulated pipe, it is not necessary to take off all of the insulation. The insulation can be cored or cut out in spots where drill holes are desired, after which the insulation can be replaced by a plug which will show the leakage if and when it occurs. In some instances nipples have been tack welded on the pipe to allow the leaking fluid free access beyond the insulation but this is expensive, and a method of either putting plugs in the insulation or making a parting between sections of insulation has been found to be quite satisfactory and inexpensive.

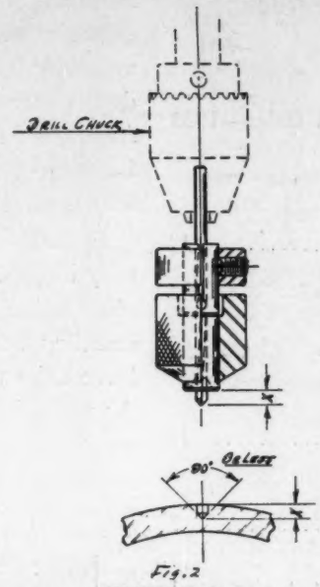


FIGURE 2

Details of standard drill with specially tapered drill point.

Although records for 1932 are as yet incomplete, as previously stated information is now available on about 150 failures which have been detected by means of safety drilling. A few representative cases will be presented at this time.

One refiner reports 63 failures during 1932, of which 16 were detected by failure at the drill holes and 47 were caught by safety inspection. It is evident from this that, although inspection methods in this particular company are very effective and some of the 16 failures might have been discovered by that method, nevertheless in more than 25 per cent of the cases the drill holes safeguarded the equipment.

Another refiner reports 33 failures during 1932 detected by failure at the drill holes. Unfortunately the number of failures discovered by normal inspection is not available. In this case, however, it may be said that the prevalence of spotty corrosion, which is extremely difficult to detect by normal inspection, greatly enhanced the value of safety drilling. The points in the equipment at which the drill holes gave warning of potential failure are tabulated in Table I. This table enumerates data which is typical of information on drill hole failures now on record.

A large number of failures have been found to occur on the circulating pump discharge line, a point where corrosion might not be expected to be especially prevalent. It is felt that more extensive use of safety drilling would not only provide the required safety, but would in addition furnish valuable information on the causes of seemingly excessive and unwarranted corrosion.

It has been generally found that piping is particularly subject to corrosion and erosion on the downstream side of valves, fittings, flanges and the outside radii of bends. Occasionally, however, a thin spot will develop at a point and in a manner which appears to be without rhyme or reason. It seems unquestionably a fact that thin spots result from a combination of both erosion and corrosion and any point

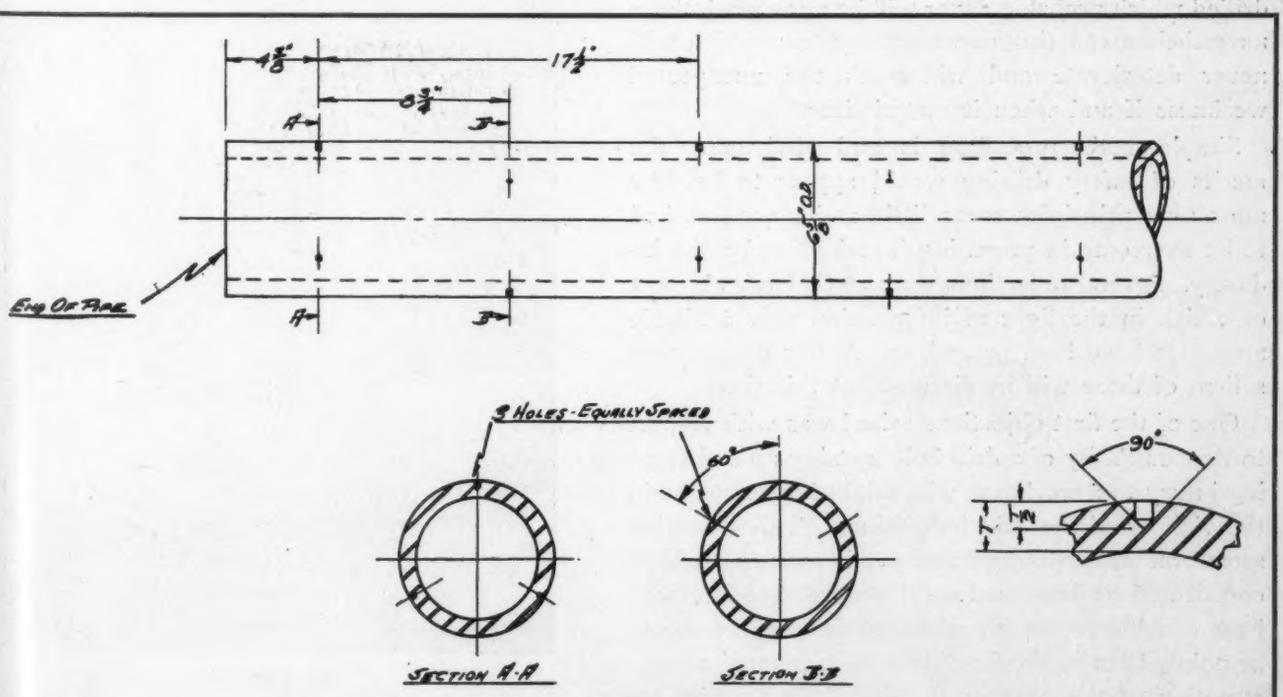


FIGURE 1

Typical pattern for 6⅝" O. D. pipe and details of safety drilling.

TABLE I.

SAFETY DRILLING

Shut Downs of Stills Due to Failure at Drill Holes—1932

STILLS—BATTERY "A" Cracking Gas Oil	
2—Discharge from heating element	
7—Pump discharge	
1—Pump suction	10
STILLS—BATTERY "B" Cracking Gas Oil	
1—Circulating line	
1—Partial Cond. vapor line	
1—Between conv. and rad. section	
1—Convection section nozzle	
2—Convection section to rad. section	
1—Outlet from convec. section	
4—Vapor lines	11
STILLS—BATTERY "C" Cracking Gas Oil or Crude	
2—Transfer line	
3—Normal line	5
STILLS—BATTERY "D" Cracking	
1—Vapor and Cond. line—Exch. and fract. tower	1
STILLS—BATTERY "E"	
1—Circ. oil line pump to heat element	1
STILLS—BATTERY "F" Crude with Gas Oil Coil	
1—Cond. line—crude vapor heat exchangers	1
STILLS—BATTERY "G"	
1—Discharge line from reboiler tank	
1—Cond. line—Red. crude vapor exchangers	
2—Conv. to rad. and soak section	4
Total during 1932	33

where turbulence occurs is particularly favorable for thin spots. It is felt that the only satisfactory solution of the problem lies in drilling in accordance with regular patterns and that, although many holes are drilled which probably never will be uncovered, these nevertheless constitute an alarm system, which will never deteriorate and will catch the unexpected weakness if and when it materializes.

Simple as the procedure is and obvious as the merits of safety drilling would appear to be, like most new principles some little resistance has had to be overcome in procuring its adoption by the industry. Several objections were at first raised, most of which in the light of information now available appear to have been groundless. A few of the most salient of these will be discussed at this time.

One of the first objections raised was with respect to the possibility of a drill hole opening up and causing injury to a workman who might happen to be in the vicinity of the drill hole failure. This objection seems rather far-fetched and yet it appears to have constituted at least a mental hazard to some who have considered the use of safety drilling. It should be pointed out in the first place that the conical construction of the base of the drill hole permits the discharge of only a very small amount of material when the hole is first uncovered. In time, if the corrosion is permitted to continue unchecked, it is conceivable that the opening might attain the full diameter of the hole, but this would require several days of free leakage. In any event, the leakage itself from the full bore of a one-eighth-inch hole would be far less of a hazard than the weakening of the wall which might result in an explosion or fire.

In further substantiation of the above argument it may be said that after two years' experience and the observation of a considerable number of failures no one has been injured and no dangerous conditions have arisen from the functioning of the drill holes. As a special test three operating lines in one refinery were drilled almost through so that leaks would develop in a very short time. The report on this test

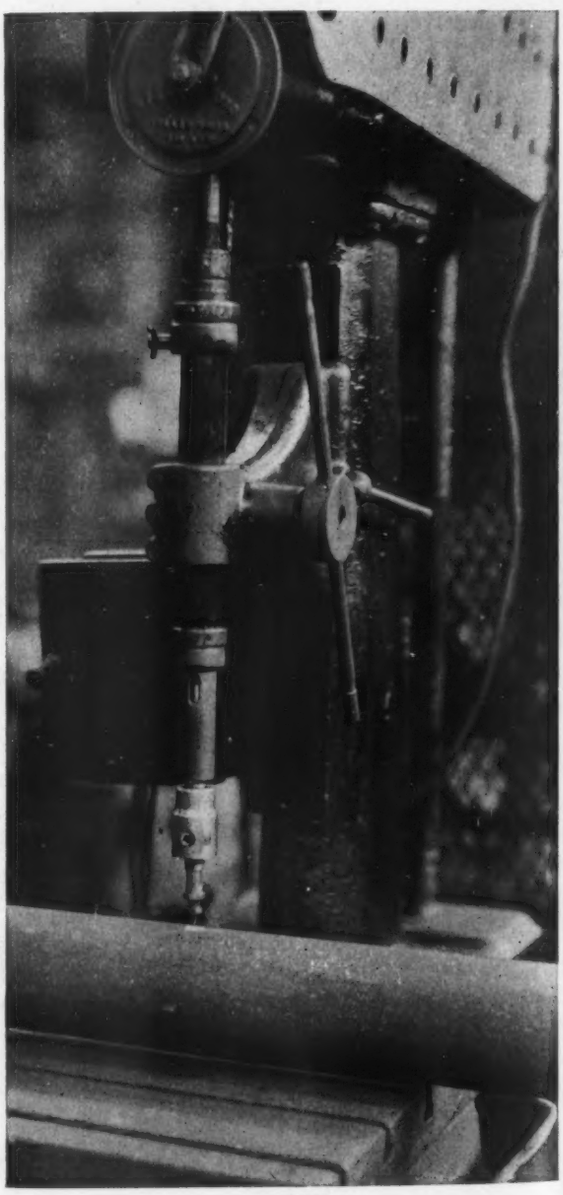


FIGURE 4

Showing the tube in position to be drilled on sensitive drill press, using drill depth limit attachment designed especially for this operation.

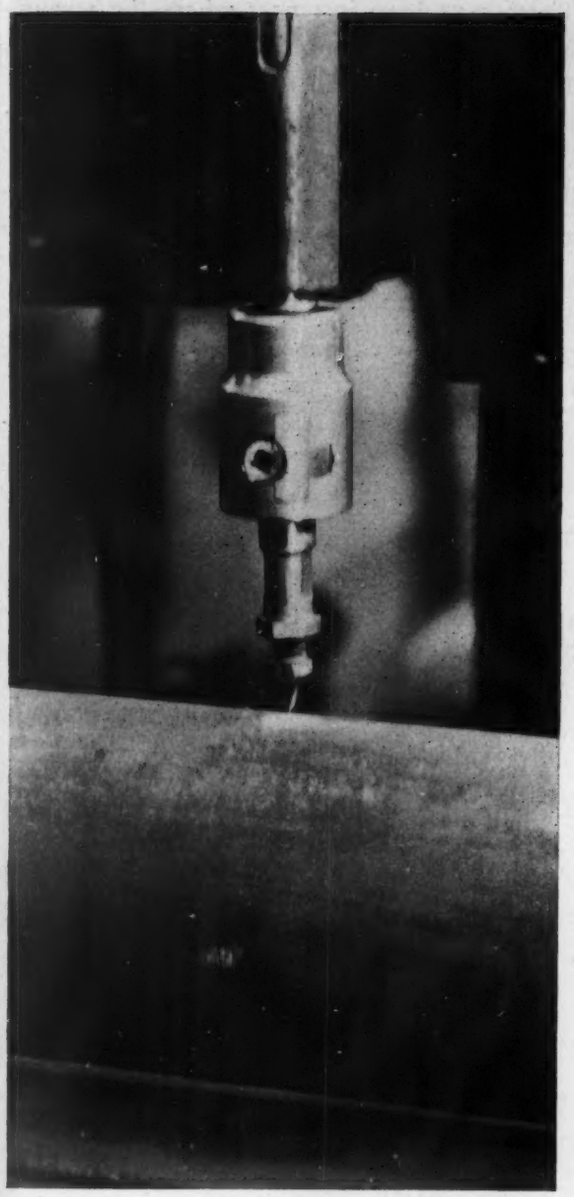


FIGURE 5

Drill chuck and depth limit attachment. The depth limit attachment is telescoped over the drill and secured by set screw. The lower part of the attachment is threaded to screw in and out of sleeve, and a lock nut holds it in position to allow the drill to project the desired depth of the hole.

stated that: "The three lines developed leaks by a small amount of vapor mist escaping. Nothing occurred of a violent nature that would indicate that there was any danger involved in the use of safety drilling."

Another objection which has been raised was with regard to the expense required to install the drill holes and vent them to the air. The availability of suitable electric drills of the type previously described makes the drilling of equipment in place a very simple operation. In one large refinery, where safety drilling has been applied to all high pressure units, equipment for about 100,000 barrels per day cracking capacity was drilled during a period of slightly more than three months with a crew of four men. This work was carried on without interfering with normal operation, each unit being drilled during a regular down period. As previously stated, experience has shown that it is unnecessary to vent the drill holes individually. They may be covered by insulation, under which conditions leakage occurring at any one of the drill holes will either pass through the insulation in a reasonable time, or follow along the pipe until a break, such as a flange, occurs and give evidence of pipe failure by smoking or steaming insulation. It should be remembered that the drill holes give warning sufficiently in advance of the creation of a dangerous condition as to provide ample time for detection and remedy.

As a further incentive to the extended use of safety drilling, arrangements have been made whereby it is now possible to purchase pre-drilled pipe, tubing and bends. The manufacturers of this pre-drilled equipment report that, notwithstanding the lethargy in refinery construction during the past year, a substantial number of inquiries have been received and a satisfactory number of purchases made.

Question has been raised as to whether or not the drill hole will function if the pipe is carbonized. Examination of a large number of failures and sections of corroded piping has evidenced that where the pipe is coated with carbon or scale no corrosion takes place. In cases where spotty corrosion has been observed, the metal has been clean showing no sign of carbon or scale. Obviously, under these conditions the drill holes would have operated, as experience shows they did operate where conditions warranted.

It has been objected in some quarters that there is a possibility of concentration of stresses around drill holes with consequent weakening of retaining metal. Although calculations of the amount of metal removed indicate that the weakening of the pipe for this cause is well within the usual tolerance of the wall gauge and for all practical purposes is negligible, and actual operating experience to date has shown no tendency to concentration of stresses at drill holes, it was deemed advisable definitely to answer this question by means of actual bursting tests.

These tests, conducted by National Tube Company, the results of which have just been made available, definitely show that safety drilling has no effect on the bursting strength of the tubes.

The test procedure and results are briefly outlined as follows:

Three pieces of 6⅝-inch tube, approximately 24 diameters in length and having a wall thickness of

0.432-inch were cut in two, one half being drilled with one-eighth-inch holes to one-half the depth of the nominal wall thickness, with a tolerance of plus one-sixty-fourth-inch and minus 0 inch. The drilling was on a spiral with a 12-inch pitch, each helix comprising four holes, spaced three inches apart along the length and 90 degrees apart around the periphery. Under these conditions each specimen contained 24 holes, one for each 62½ square inches of external surface.

Chemical analyses and tensile tests for the samples were as follows:

	ANALYSIS				TENSILE TESTS		
Sample No.	Car.	Mn.	Phos.	Sul.	Yield point lbs. sq. in.	Ult. strength lbs. sq. in.	Elongation in 2 in.
1	.12	.54	.012	.024	40,190	56,520	56.0
2	.12	.54	.013	.025	37,130	55,980	48.0
3	.14	.51	.015	.031	37,190	60,640	47.0

The six pieces, three drilled and three undrilled, were fitted with welded heads and subjected to hydrostatic bursting tests with the following results:

Sample No.	Safety drilled lbs.	Not drilled lbs.
1	7,900	7,900
2	8,600	8,360
3	7,880	7,820
Average	8,127	8,027

The above data leads to the obvious conclusion that the safety drilling of piping does not weaken it.

There have been instances where the purpose of safety drilling has been misunderstood to the extent that it has been considered as a substitute for inspection or to indicate thinning of a pipe at points where corrosion is likely to occur. While safety drilling will perform this function, it should be called upon to do so only as an adjunct to regular safety inspection. Its greatest value lies in the fact that it eliminates the necessity of reliance on human judgment as to where equipment should be inspected. It serves its correct purpose and attains its intended objective only when applied in the form of drill holes of correct diameter, depth and spacing properly distributed throughout the equipment to be safeguarded.

Experience has taught that, like the proverbial example of the unloaded gun, the most disastrous accidents frequently result from failure at unexpected points under seemingly unwarranted conditions. Safety drilling is, in a measure, like a burglar alarm which, it is hoped, will never be required to function but which will function when conditions necessitate regardless of what part of the system sets it off. It unquestionably constitutes the cheapest form of insurance to life and property yet devised since it does not deteriorate, does not weaken equipment and does not relax its vigilance.

This view shows a tube on which the positions of the safety drill holes are being located by means of the layout jig or template. Position of the first pair of holes adjacent the end is located and punch marked. The jig or template is then slipped over the tube and, by aid of the punch, the locating hole in jig is made to coincide with the punch mark.

Welding Corrosion-Resistant Irons and Steels

JAMES CAMPBELL HODGE, D. Sc.
Chief Metallurgist, The Babcock & Wilcox Co..

THE welding of alloy steels has progressed tremendously within the past few years. The development of efficient electrode coatings for protection of the molten metal has materially contributed to this advance. Yet care in the heat treatment of welded structures and in the matter of choice of a particular stainless alloy for any application must be exercised. The stainless alloys have paid their way and have a permanent place in industry in spite of set backs due to improper handling or improper application.

One or more of the welding processes is usually used in the fabrication of equipment involving corrosion resistant irons and steels. If not used in the fabrication of a part, welding will be used as a repair method after some period of service of the part. The welding of these irons and steels should, therefore, be of interest to the refiner. Inasmuch as the metal arc welding process is used to the greatest extent in welding the corrosion resistant alloy steels, this discussion will deal largely with this process, and other types of welding mentioned only where conditions give them preference.

METALLURGICAL SYMPOSIUM

THE active corrosive agents in refining processes have been fairly well established as sulphur and sulphur compounds, mainly hydrogen sulphide and hydrochloric acid resulting from salt in aqueous solution. The corrosion from the sulphur compounds is most marked at high temperatures, and the corrosion from hydrochloric acid is prevalent at low temperatures in the presence of moisture. Special cases of corrosion have been noted from time to time involving naphthenic acids as the corrosive agent.

With the corrosive agents identified the corrosion resistant alloys best suited for service at the various points in the refining processes have been determined at least in a general way. The first cost of these corrosion resistant alloys has in many cases precluded their use from certain parts of refining equipment, where the increased life of the equipment resulting from the use of the expensive alloy is not believed warranted due to probable early obsolescence of the equipment used in the refining process. Nevertheless, corrosion resistant alloys have found extended application in parts of the process:

(1) Where the corrosion rate is enhanced by high temperature and where the higher creep values of the corrosion resisting alloys are of great value such as in the tubular heating elements of cracking still equipment. For the latter use the austenitic chromium alloy steels are particularly well adapted.

(2) Where the parts are subject to high velocities and where corrosion is increased by erosion, such as in return bends, reaction chamber nozzles, and valves, all operating at high temperatures; and in lower temperature tubular equipment such as condensers, coolers and other heat exchangers.

It may be reasonably expected that the cost of the corrosion resistant alloys will decrease to some extent as the increasing demand for these alloys will permit more efficient production on the steel manufacturer's part with resultant more extended use for oil refinery service.

All of the fusion welding processes involve the heating of the parent metal to high temperatures, followed usually by rapid cooling. For this reason discussion of the welding of these alloys must involve a discussion of the metallurgical changes involved in heating the alloys to a high temperature and cooling rapidly to normal temperatures. In the metal arc process, changes in the chemistry of the deposited weld metal from the original composition of the electrode also occur.

CORROSION OF PLAIN CARBON STEEL WELDS

Before proceeding with a discussion of corrosion resistant steel welds, it is advisable to briefly discuss the corrosion of low carbon steel welds, inasmuch as this results from certain changes in the chemistry of the weld metal during its deposition, and the same changes also occur in the deposition of the corrosion resisting steels. During the deposition of the weld metal, the high temperature molten metal readily combines with oxygen and nitrogen of the atmosphere, oxidation and elimination of carbon, manganese and silicon readily occurring and absorption of nitrogen by the weld metal also being marked. This oxidation and nitrogenization of the

weld metal may be greatly reduced by use of covered electrodes, the final composition of the weld metal being then determined by the nature of the covering and length of arc used. A typical example of the chemical analyses of the original electrode, the bare electrode weld metal and covered electrode weld metal are given in Table 1.

TABLE 1

	Carbon	Manganese	Nitrogen
Original Electrode.....	.15-.18	.30-.60	Less than .009
Bare Electrode Weld Metal.	.02	.20	.11-.16
Covered Electrode Weld Metal.....	.08-.13	.30-.60	.015-.035

Note the marked elimination of carbon and manganese caused by oxidation and the absorption of nitrogen in the case of the bare electrode weld metal. The protection afforded by the covered electrode is indicated by the higher carbon and manganese contents and by the lower nitrogen values.

The general experience with bare electrode weld metal indicates that it corrodes more rapidly than the plain carbon parent metal. The author believes that this is due to the numerous small electrolytic cells set up between the small needle-like nitride constituents and the ferrite of the weld metal (Figure 1.) Again . . . the general experience with covered electrode weld metal indicates that it resists corrosion at least as well as that of the parent low carbon steel. Figure 2-A shows a deeply etched section through a weld in a 1½-inch thick plate, in which the various beads of weld metal have been differentially etched or corroded by the boiling 1:1 hydrochloric acid used in etching. On investigation it was found that the dark deeply corroded weld metal beads possessed high nitrogen contents and showed nitride needles under the microscope (Figure 2-B), while the lightly etched uncorroded weld metal possessed low nitrogen contents with no nitride constituent observable under the microscope (Figure 2-C).

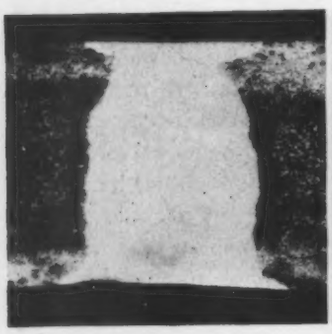


FIGURE 1A
Low carbon steel weld fully protected during deposition. Deeply etched with 1:1 HCl. The weld metal is not attacked to the same extent as the plate.

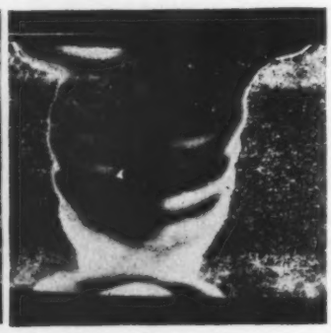


FIGURE 1B
Low carbon steel weld incompletely protected during deposition. Deeply etched with 1:1 HCl. The weld metal is more deeply attacked than the plate.

FIGURE 2A
1½" steel plate metallic arc welded. Etched with 1: HCl. Black areas are high in nitrogen.

FIGURE 2B
Nitride needles in weld metal which corroded readily. Etched in 4% Nital. Magnification 500x.

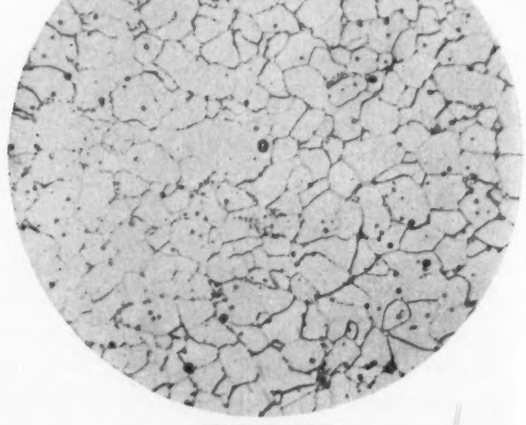


FIGURE 2C
Structure of weld metal resistant to corrosion. Etched in 4% Nital. Magnification 500x.

All of the weld metal was deposited from the same type of covered electrode and the variations in nitrogen content and in the resultant corrosive attack were due to changes in the length of the arc by the operator during the deposition of the individual beads. The above may be of assistance in determining the reasons for the sometimes widely varying behavior of low carbon steel welds with respect to corrosion.

CHEMISTRY OF CORROSION-RESISTANT WELD METALS

The changes in chemical composition described for the low carbon steel welds due to oxidation and absorption of nitrogen proceed to a greater extent in the deposition of the corrosion resistant alloys, which usually contain large amounts of at least one readily oxidizable element such as chromium. Chromium also has a marked affinity for nitrogen, the nitrogen content of some 18 per cent chromium eight per cent nickel weld metals being as high as 0.25 per cent. Coated electrodes are, therefore, generally employed in the deposition of the chromium irons and steels to prevent excessive losses in chromium due to oxidation and to prevent excessive absorption of nitrogen. The electrode coating or covering usually contains an element possessing a preferential affinity for oxygen and nitrogen such as ferro-manganese, ferro-titanium, or aluminum. Carbon bearing compounds are usually eliminated from the coating as carbon is readily absorbed by the weld metal, and low carbon is usually a prime requisite for the securing of successful corrosion resistance of these alloys. The molten slag formed by the coating also protects in a purely mechanical way by preventing contact of air with the liquid weld metal.

For purposes of discussion the commercial high chromium and high chromium-nickel irons and steels may be grouped as in Table 2. In the following discussion of the welding of these alloys any statement regarding the weldability or non-weldability of any alloy must be considered as possessing limitations. For example, the 28 per cent chromium irons are usually considered as non-weldable. Even a moderate sized pressure vessel could not be constructed of 28 per cent chromium iron, but small installations not subject to much pressure may be welded satisfactorily for the service involved.

The 4-6 per cent chromium irons, the 18 per cent chromium irons, and the 18 per cent chromium eight per cent nickel and related alloys are the most important commercially and will be discussed at greater length than the other alloys.

TABLE 2

Group		Carbon	Chromium	Nickel	Special Element
1	4-6% Cr	Up to .35	4–6%		Tungsten up to 1% or Moly. .40-65%
2	12% Cr	Less than .12	12–14%		
3	16% Cr	Less than .12	14–16%		
4	18% Cr	Less than .12	17–19%		
5	28% Cr	Less than .30	27–30%		
6	18 Cr-8 Ni	.05-.15	17–20%	7.5-9.0	Titanium .30-.75 Molybdenum 1.5-3.0
7	25 Cr-20 Ni	.10-.20	24–26%	19–21%	
8	8 Cr-20 Ni	.08-.15	8– 9%	19–21%	

GROUP 1: 4-6 PER CENT CHROMIUM IRONS

Alloys of this group are manufactured in several grades with respect to carbon content, the carbon ranges being between 0.10 and 0.35 per cent. Tungsten or molybdenum additions may be used for improvement of creep strength at high temperatures or for prevention of temper brittleness. The alloy possesses distinct air hardening tendencies, and as carbon enhances the air hardening propensity of this alloy the lower carbon ranges of the alloy are generally chosen where welding is to be considered. Due to the air hardening of the affected zone of this alloy and of the weld metal, this group may be considered as possessing only limited weldability. Danger of cracking of the weld metal or of the affected zone of the parent metal is always present. Sections of moderate size may be welded without danger of cracking. It would not be advisable, however, at the present state of the welding art to consider the welding of an extremely large pressure vessel of this alloy, even if economically feasible.

Annealing of the finished welds should always be employed to produce maximum ductility and softness. Annealing may be accomplished by heating to 1650°F., followed by slow furnace cooling at a rate not to exceed 100°F per hour, until a temperature of 900 to 1000°F. is reached, after which the part should be reheated to 1350°F. and withdrawn from the furnace and air cooled to prevent possible temper brittleness. A second method of annealing consists of heating to just below the lower critical point (or approximately 1300°F.) for a long period of time, followed by air cooling.

When difficulty is encountered due to the cracking of the weld metal, when using 4-6 per cent chromium electrodes, an 18 per cent chromium eight per cent nickel electrode may be substituted to eliminate the danger of cracking. The use of this electrode, however, assumes (1) that the welded part may be used in the as-welded condition without further heat treatment, as the annealing temperature suitable for 4-6 per cent chromium irons places the 18 per cent chromium eight per cent nickel weld metal in its poorest condition for corrosion resistance, due to carbide precipitation, and the annealing treatment for the 18 per cent chromium eight per cent nickel weld metal, i.e., rapid cooling from 1850 to 2100°F. would result in hardening of the 4-6 per cent chromium material; and (2) that the service conditions and design of the welded part will not cause final failure in

service due to the difference in coefficients of expansion of the two materials.

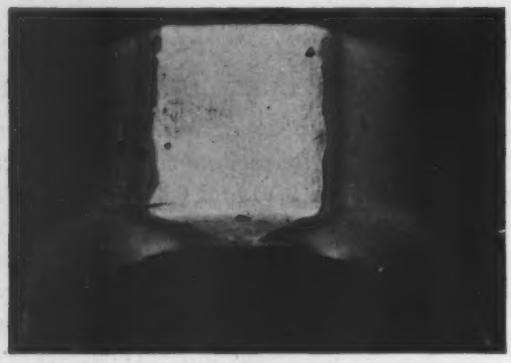


FIGURE 3A
Bend test of 4-6% plate chromium steel welded with 18 Cr 8 Ni steel electrodes.

Figure 3-A shows a bend test on a specimen weld of 4-6 per cent chromium iron in which the austenitic 18 per cent chromium eight per cent nickel welding electrodes have been used. Figure 3-B is of a bend

FIGURE 3B
Bend test of 4-6% chromium steel plate welded with 4-6% chromium steel electrodes.

test welded with 4-6 per cent chromium steel electrodes. The bending qualities are excellent and other physical properties are very good. Table 3 lists typical properties for such welded alloys properly heat treated.

TABLE 3

Yield Point lb./sq. in.	Tensile Strength lb./sq. in.	Elong. in 2"	Brinell Hardness		Remarks
			Weld	Plate	
40,000	75–80,000	30%	150–200	140	Usually breaks in plate.

The 4-6 per cent chromium steels cannot be considered as stainless steels. However, for certain applications the resistance to corrosive attack is sufficiently superior to that of the carbon steels to warrant its use. Many of the seamless tubes used in still tubes and formerly made from carbon steel are now manufactured using the 4-6 per cent chromium alloy containing molybdenum additions.

GROUP 2: 12 PER CENT CHROMIUM IRONS

To secure an alloy steel stainless to oxidizing influences it is necessary to have a minimum chromium content of approximately 12 per cent. Such an alloy is not favored in the oil industry because of the failure to respond readily to heat treating. This is an air hardening steel, and after welding the weld metal and adjacent areas are very hard and brittle and

FIGURE 4
Martensitic structure of 12% chromium steel weld metal in the as-welded condition. Brinell Number, 500. Etch: Acid ferric chloride. Magnification, 500x.

liable to cracking. Figure 4 reveals the martensitic structure of a 12 per cent chromium alloy steel in the as-welded condition.

GROUP 3: 16 PER CENT CHROMIUM IRONS
GROUP 4: 18 PER CENT CHROMIUM IRONS

Because of this difficulty and also because a much greater corrosion resistance at slightly increased cost is secured, steels of Groups 3 and 4 with chromium ranging from 15 to 18 per cent have met a more enthusiastic reception. Such alloys weld without difficulty and readily respond to heat treatment. Although brittle as welded, a simple annealing treatment at 1500°F. confers considerable ductility and impact resistance. Table 4 gives an idea of what may be expected of welded 18 per cent chromium iron before and after proper heat treatment.

TABLE 4

SAMPLE	Tensile Strength lb./sq. in.	Elongation in 2", %	Charpy Impact Values: ft-lbs.	Remarks
Plate.....	70,000	30	35	
Transverse Weld Specimen as welded.....	70,000	10 (Across weld)	4	Break in plate.
Transverse Weld Specimen annealed	70,000	20 (Across weld)	20	Break in plate.

The microstructures of three such welds are shown

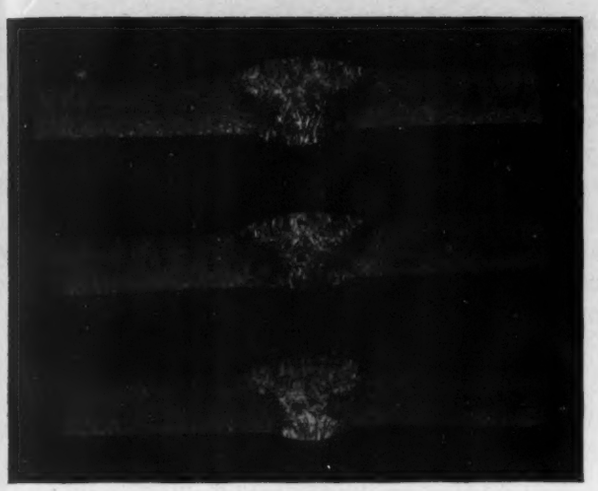


FIGURE 5A
Microstructures of three 18% chromium welds:
A. W. = As welded.
1500 = Annealed 1500° F.

in Figure 5-A. In Figure 5-B is shown the typical structure of annealed plate, Figure 5-C is of the plate in a zone affected by welding heat. Figure 5-D reveals the coarse grained character of the weld metal itself. Although the grains are large, the tensile strength is superior to that of the plate, and the ductility and impact resistance are satisfactory. These alloys have excellent resistance to the action of such gases as hydrogen sulphide and sulphur dioxide.

GROUP 6: 18 PER CENT CHROMIUM, 8 PER CENT NICKEL

GROUP 7: 25 PER CENT CHROMIUM 20 PER CENT NICKEL

The best of the straight chromium alloy steels are burdened by several inherent faults which no mechanical treatment or heat treatment will remedy. Previously it has been stated that chromium alloys when the chromium content is 12 per cent or over are stainless. This statement applies, however, only when the corrosive medium is of a purely oxidizing character as exemplified by nitric acid or atmospheric influences. Such alloys have little or no resistance to the action of mineral acids such as hydrochloric and sulphuric acids. Their creep strength limit at elevated temperatures is also low although somewhat superior to that of carbon steels. Another disadvantage is the embrittling action resulting from continued exposure to high temperatures.

The development of the austenitic chromium nickel alloys has opened a new field in metallurgical development. These alloys containing a minimum of 18 per cent chromium and eight per cent nickel are being adapted to many applications requiring excellent physical properties and high corrosion resistance. These alloys possess to an enhanced degree the stainlessness of the straight chromium steels under oxidizing conditions as well as good resistance to mineral corrosive attack which the others lack. They are strong, extremely ductile and very resistant

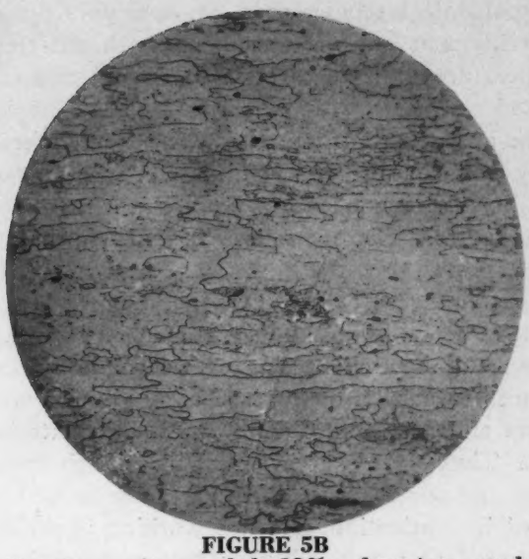


FIGURE 5B
Structure of annealed 18% chromium steel plate. Etched: Acid ferric chloride. Magnification, 100x.

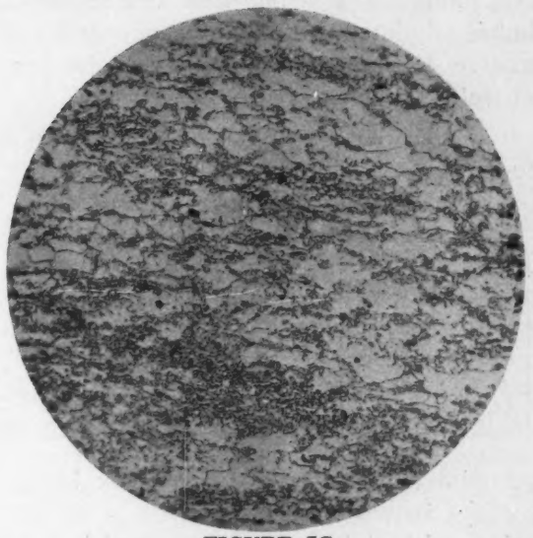


FIGURE 5C
Structure of 18% chromium steel plate adjacent to the fusion zone of the weld metal. Ferrite and carbide (Troostite). Etch: Acid ferric chloride. Magnification, 100x.

FIGURE 5D
Coarse grained weld metal 18% chromium steel. Ferrite and carbide (Troostite). Etch: Acid ferric chloride. Magnification, 100x.

to shock. High temperature exposure does not cause embrittlement and the creep strength at elevated temperatures is from three to five times that of carbon or straight chromium steels. The metallurgy of the austenitic chromium nickel alloys differs radically from that of the chromium steels. Softness and ductility are imparted by rapid cooling from high temperature. There are two distinct forms which iron assumes, one, the high temperature variety, being extremely soft and ductile, the other low temperature from being harder and more brittle. The presence of the nickel acting with chromium prevents the transformation of the iron alloy which normally occurs and a strong, ductile and tough material results. These alloys are very rigid at high temperatures, and for this reason much more power is required in fabrication, and hot working is ordinarily performed at a much higher temperature than for carbon or straight chromium steels. The alloys weld readily, producing a strong and ductile weld. In Table 5 is tabulated some physical properties of representative 18 per cent chromium eight per cent nickel welded plates.

TABLE 5

Physical Properties of 18% Cr, 8% Ni Welds
Transverse Specimens

Weld No.	Heat Treatment	Tens. Str. lb./sq. in.	Elongation in 2" across weld	Remarks
1	Air cooled 1850°F.	90,000	30-40.0	Broke outside of weld.
2	Water quenched 2100°F.	85,000	35-50.0	Broke outside of weld.
3	As welded	90,000	20-30.0	Broke in weld

Approximately the same values may be secured with alloys between the ranges 18 to 26 per cent chromium with eight to 20 per cent nickel. Proper heat treatment to retain maximum corrosion resistance is dependent to some extent upon the service involved. For elevated temperature service it is desirable to retain a small grain size, and for this reason air cooling from 1850°F. is the treatment usually applied. For maximum resistance to corrosion at low temperature, a water quenching treatment from 1900 to 2100°F. is advisable. The higher the carbon content of the alloy, the higher the quenching temperature should be. The quenching retains the carbon in solid solution.

CARBIDE PRECIPITATION

When any of the chromium-nickel austenitic steels are heated to within the temperature range 1000 to 1600°F. a precipitation of carbon in the form of car-

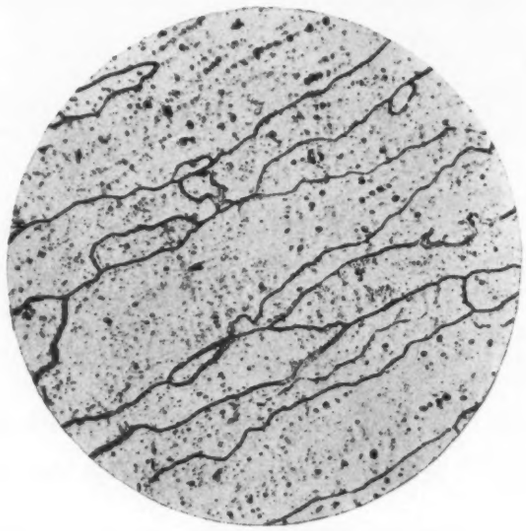


FIGURE 6B

Structure of metallic arc welded 18% Cr 8% Ni alloy. Etch: Aqua Regia in glycerine. Magnification, 100x.

FIGURE 6A

Structure of metallic arc welded 18% Cr 8% Ni alloy. Etch: Aqua Regia in glycerine. Magnification, 40x.

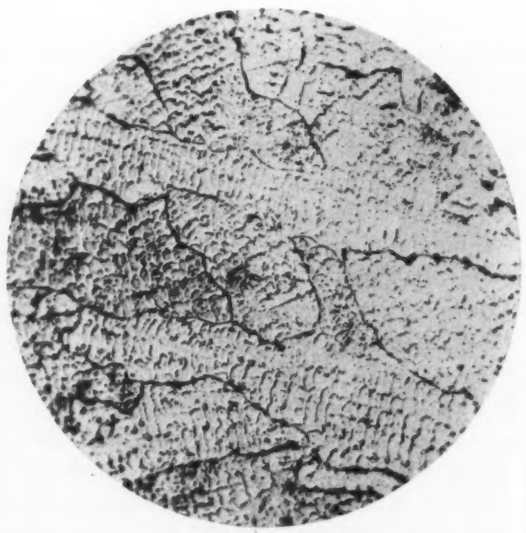


FIGURE 6C

Structure of weld metal 18% Cr 8% Ni alloy. Etch: Aqua Regia in glycerine. Magnification 100x.

bide occurs. This carbide migrates rapidly to the grain boundaries of the metal where it collects. The chromium, which is needed to form the chromium carbide, is taken from the areas immediately surrounding the grain boundaries, resulting in a lowering of the corrosion resistance at such places. When the metal in such condition is exposed to the action of an active electrolyte rapid corrosion at such areas occurs and the steel suffers intercrystalline corrosion. The actual weight loss may be so little as to be imperceptible upon casual examination, but cohesion between the grains of the metal has been destroyed and it is in a dangerously weak condition. Because of the possibility of the occurrence of this phenomenon the high temperature treatment is necessary apart from any physical improvements secured.

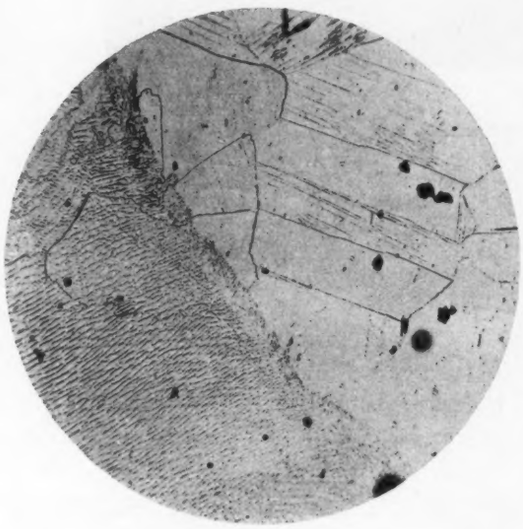


FIGURE 6D

Microstructure at junction of plate and weld 18% Cr 8% Ni alloy. Etch: Aqua Regia in glycerine. Magnification, 100x.

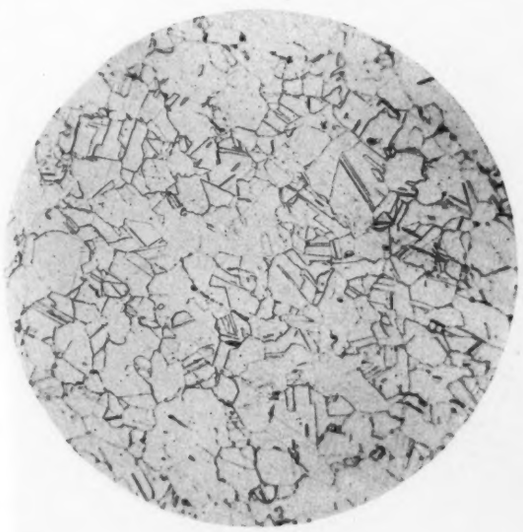


FIGURE 6E

Original structure of 18% Cr 8% Ni alloy plate. Etch: Aqua Regia in glycerine. Magnification 100x.

Because the presence of carbon is the prime factor in the occurrence of intercrystalline corrosion, effort is made to keep the carbon content as low as possible especially for applications where welding is to be employed. Welding heat will invariably cause the precipitation of carbides in some part of the plate, immediately adjacent to the weld, where the temperature is within the precipitation range (1000 to 1600°F). The weld metal itself due to very rapid cooling is not so apt to be affected. Such welded material must then be heat treated to place the precipitated carbide in solution, completely restoring corrosion resistance. There are many possible applications where heat treating after welding is extremely inconvenient or impossible. It has been found that the addition of titanium in an amount equivalent to about six times the carbon content is effective in retarding the precipitation of carbide during welding. It is especially effective where the thickness of the plate does not exceed one-eighth-inch. Continued heating will, however, cause precipitation with consequent deterioration under corrosive conditions. The grain size of the weld metal is enormous as no recrystallization occurs during cooling from the liquid state. Figure 6-A and Figure 6-B at 40 and 100 diameters respectively, show the grain size resulting after metal arc welding using coated electrodes of the same analysis of the plate. Figure 6-C is another view of 18 per cent chromium eight per cent nickel weld metal. When proper protection is secured during welding, little change in chemical analysis occurs except for a usual slight loss of chromium. Figure 6-D is typical of the micro structure at the weld junction. Figure 6-E shows the original structure of the plate before welding. In Figure 6-F are shown the microstructures of two heavy

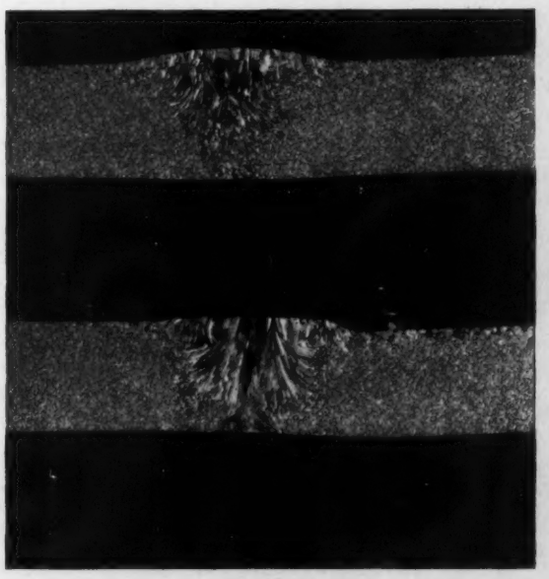


FIGURE 6F

Microstructures of two metallic arc welded tubes 18% Cr 8% Ni alloy.

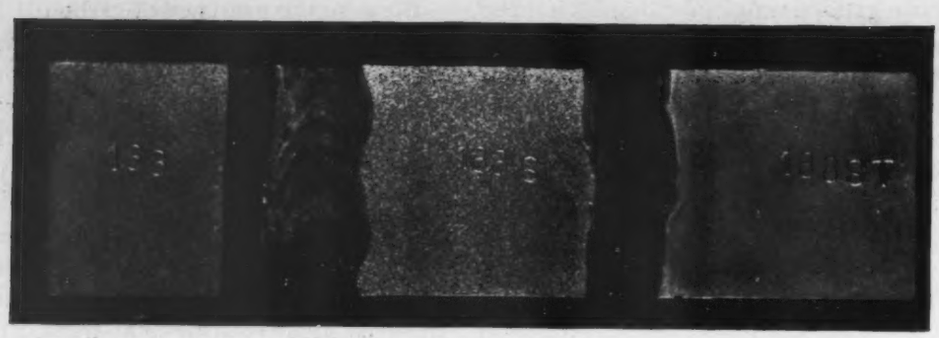


FIGURE 7A

Top view—Three grades of 18% Cr 8% Ni alloy steel welded and tested in copper sulphate, sulphuric acid solution.

FIGURE 7B

Side view—Same as Figure 7A.

walled tubes after welding by the metallic arc process. Figure 7-A and Figure 7-B are top and side views of a welded specimen made up of three grades of 18-8 plate; 18-8 with high carbon (0.12 per cent) marked 18-8; 18-8 with low carbon (0.06 per cent) marked 18-8S, and 18-8 low carbon containing titanium marked 18-8ST. After welding the sample was immersed in a water solution of 10 per cent copper sulphate and 10 per cent sulphuric acid. Note the differences in corrosive effect caused by analysis changes with respect to carbon and titanium.

For some extremely severe corrosive conditions where the 18-8 analyses have proven unsuitable, it has been found advantageous to increase the amounts of chromium and nickel. Molybdenum additions in amount ranging from 1.5 to 3.5 per cent have proven valuable in increasing resistance to mineral acid corrosion. These alloys weld readily and in a manner similar to that of 18-8, but in general the resultant physical properties are slightly inferior to 18-8 welds.

The chromium-nickel austenitic steels may be successfully resistance welded to low carbon steel. Figure 8-A. A hard martensitic transition zone exists between the two alloys. Figure 8-B. Almost invariably, however, such a weld will break in the carbon steel at a point removed from the weld.

STAINLESS CLAD MATERIALS

For particular applications where strength requirements necessitate the use of heavy plate, economical resistance to corrosion may be obtained by

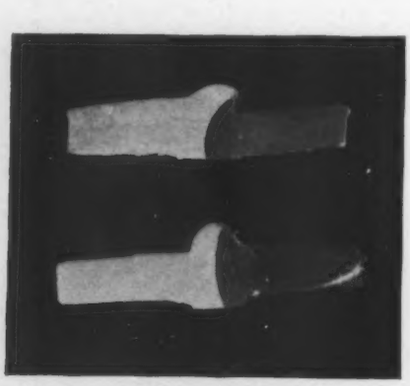


FIGURE 8A

18% Cr 8% Ni alloy steel welded to low carbon steel. Etched with ammonium persulphate.

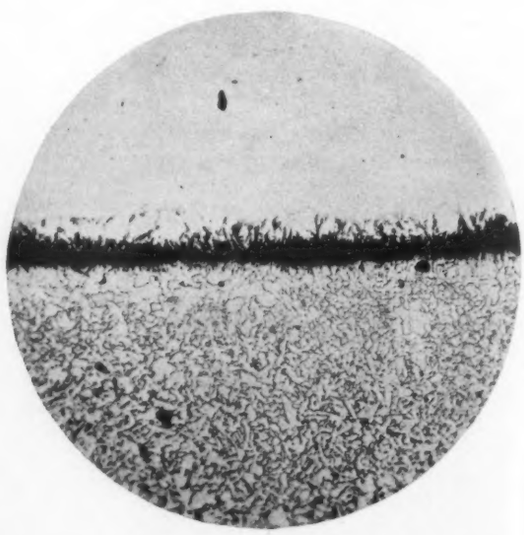


FIGURE 8B

Martensitic transition zone between 18% Cr 8% Ni alloy and the low carbon alloy — annealed. Etch: 4% Nital. Magnification, 100x.

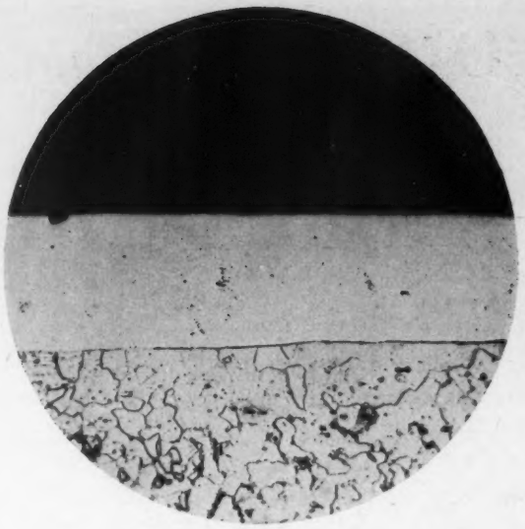


FIGURE 9A

Low carbon steel clad with 18% Cr 8% Ni alloy steel. The alloy steel is unetched. Etched with 4% Nital. Magnification, 100x.

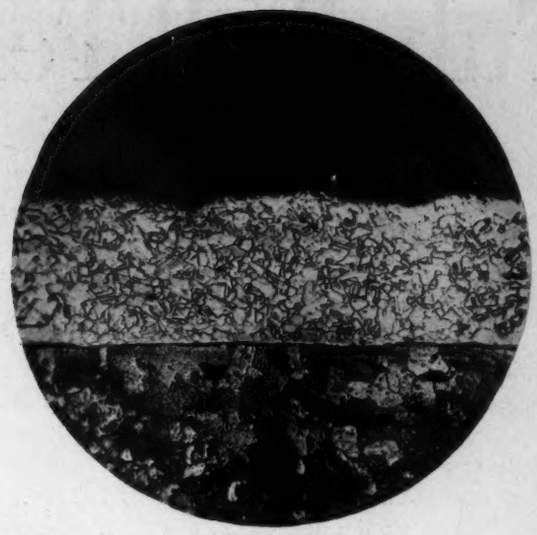


FIGURE 9B

Same as 9A. Etched with Aqua Regia in glycerine to reveal structure of the alloy steel. Magnification, 100x.

the use of carbon steel plate clad with stainless steel or with pure nickel. Figure 9-A and Figure 9-B show a low carbon steel plate clad with 18 per cent chromium eight per cent nickel alloy, which is 10 per cent of the thickness of the carbon steel. An excellent bond is obtained with little, if any, alloying of the two steels. Such a composite plate is readily welded employing low carbon steel electrodes for the steel side and 18-8 electrodes for the alloy steel side. Such a weld cannot be heat treated, however, as the proper heat treatment for the carbon steel would ruin the corrosion resistance of the alloy cladding, and proper heat treatment of the alloy cladding would embrittle the carbon steel plate.

Characteristics of Steel at Elevated Temperatures

(*Continued from page* 183)

tility at room temperature after thousands of hours at elevated temperatures have been used for years at the elevated temperatures without sign of failure.

A third effect of temperature is a reduction in ductility found in testing metal in a certain temperature range depending on the composition and the metallographical condition. Two examples of this in rather widely differing alloys are shown in Figures 5 and 6. The data for the 18 per cent Cr, 8 per cent Ni, curves was derived by Newell and that for the 28 per cent Ni, 14.5 per cent Cr, curves by Handforth. It will be noted that in both cases the temperatures of minimum ductility and the loss of ductility depends on the previous history of the metal being tested.

Tube Wall Telescope *for Examination of Interior of* Tubes and Piping

IN many cases visual inspection of the walls of tubes, pipes, chambers and other bores is the only manner of securing satisfactory information as to the condition of the interior in such a part, and often visual observation is impossible. Such inspection is rendered possible by the use of the new Carl Zeiss (Jena, Germany), Tube Wall Telescope and Tube Wall Microscope, recently introduced into this country.

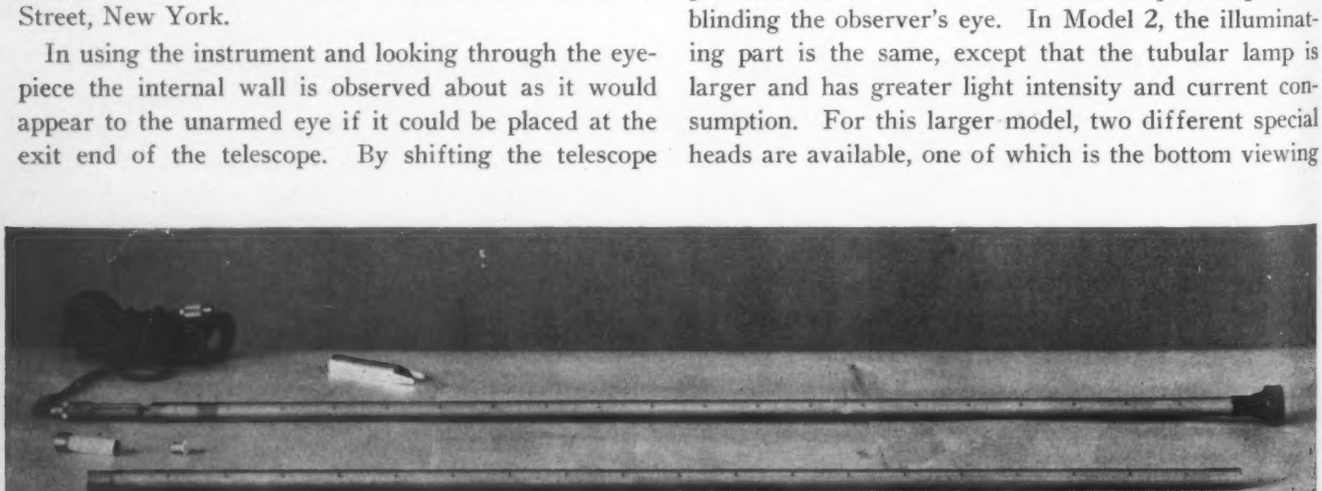
The Ziess telescope is specially designed for the inspection of the interior of pipes and tubing of customary lengths and diameters for checks, corrosion, erosion, rust pits, porous areas, dangerous laps, seams, or mandrel marks.

The first of such telescopes was brought into this country by the Calorizing Company, Pittsburgh, after a thorough investigation among American optical manufacturers and the Ordnance Department, United States Army, in their efforts to find a bore searching tool which would enable that concern to thoroughly examine the interior of seamless steel still tubes before calorizing. The device is now employed for inspection purposes by Spang Chalfant & Company, Globe Steel Tube Company and others, including some of the American refining companies. It is available in this country through the George Scherr Company, 128 Lafayette Street, New York.

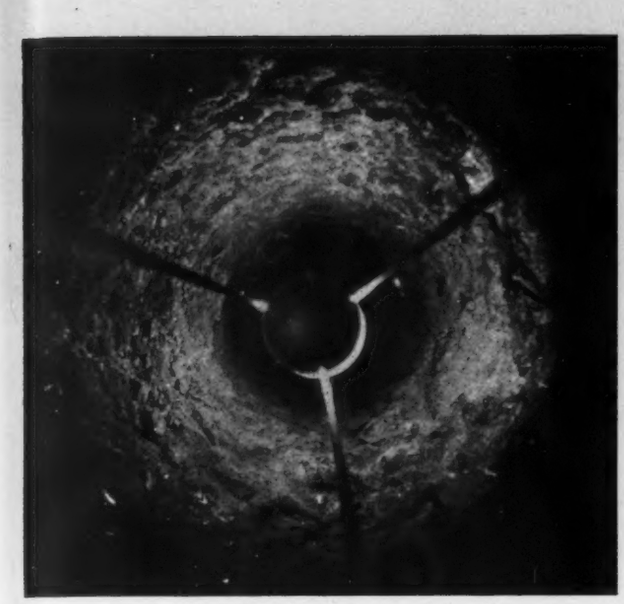
In using the instrument and looking through the eyepiece the internal wall is observed about as it would appear to the unarmed eye if it could be placed at the exit end of the telescope. By shifting the telescope along the tube different portions of the wall are brought into view and the entire inside can be successfully examined. Marks on the exterior of the telescope tube indicate at what particular point of its depth is being examined. A photographic record of any portion of the tube may also be made by means of a special camera designed for this purpose.

The body of the tube wall telescope comprises several sections, which are 3.3 feet long in Model 1 and five feet long in Model 2. By simply shoving them together, the different sections are automatically locked by the engagement of two spring pins in one section in corresponding holes in the next. With Model 1, the manufacturers recommend, is used up to not exceeding 13 feet, which is obtained by combining three extensions with the main tube. This length makes possible the examination of open pipes up to 26 feet by running the telescope in from both ends. With Model 2, the combination of the main tube with three extensions gives a maximum length of 20 feet, permitting open tubes up to nearly 40 feet in length to be inspected.

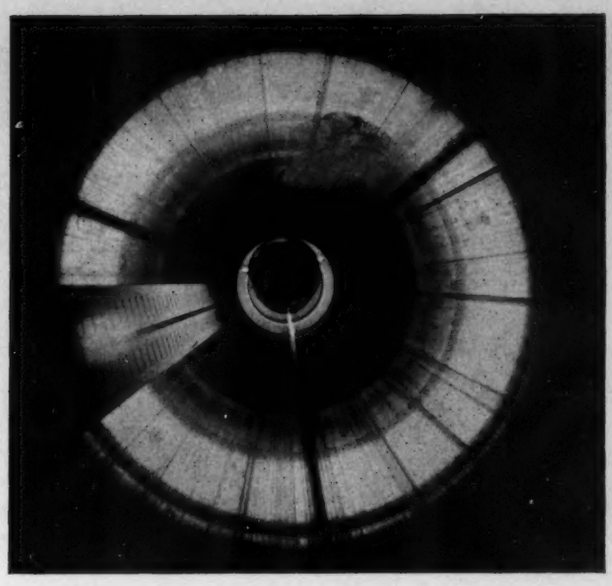
Illumination of that portion of the wall being viewed is effected by means of a readily replaceable elongated four-volt 0.4 ampere lamp with Model 1, having the point of the bulb covered with dark lacquer to prevent blinding the observer's eye. In Model 2, the illuminating part is the same, except that the tubular lamp is larger and has greater light intensity and current consumption. For this larger model, two different special heads are available, one of which is the bottom viewing



Zeiss Tube Wall Telescope showing main tube, head, two extensions, electric cord and illuminator.



Photograph made with Zeiss Tube Wall Telescope with circular view head showing corroded condition of tube interior.



Photograph of interior of new tube during inspection, made with Zeiss Tube Wall Telescope.

head and consists of a ring of four sockets for as many pocket flash light bulbs. The other is the side viewing head which contains a 90 degree prism designed to deflect the optical axis at right angles perpendicular to the tube wall. By this means, only that portion of the wall lying opposite the prism, which is illuminated by three bulbs, appears in the field of view. Current for the lamps is introduced from the opposite end of the tube through a cable ending in a screw plug fitting standard flash light or picket light lamps.

The tube wall telescope is centered in the bore by means of guide disks located on the end and at the several points, and of a diameter corresponding to the size of the tube or pipe under examination.

The magnification varies with the diameter of the bore. In Model 1 magnification is from 5.6 times for the smallest (0.7 inch) bore to 2.5 times for the largest, 1.6 inch bore diameter. In the other model the magnifying power varies as follows, five times for 1 9/16 inch; 1.2 times for four inches, and 0.6 for an eight-inch bore.

The field of view of the tube wall telescope embraces 360 degrees, or the total circular area of the section at the end of the telescope is viewed at once. The extensions are of no influence upon the size of the field of view. Focusing for different wall diameters is effected by turning the ocular ring until the wall section appears sharply defined.

The photographic equipment comprises a camera, three commercial plate holders for 2½ x 3½ inch plates, a clear glass screen with frame and a focusing magnifier. In most instances the bore is accessible from either end, but where such is not the case the current cable for illumination must be introduced from the eye end of the telescope, which requires extra space and increases the minimum diameter, when photographing interiors.

In a personal communication, B. J. Sales of the Calorizing Company, states that in the work of inspection of tubes on the bench the tube is placed on rollers and the observer sits on a stool at the eye piece of the telescope, which remains stationary while the tube is drawn backward along the bench. He suggests that in the case of many refiners where tubes are located above ground and tubes are in place, the operator and the telescope will have to move, which might be difficult to arrange. He suggests a pair of skids, or light gage track, flanged wheels on the operator's stool and cross pieces between the track similar to rungs on a ladder, so that the operator can kick himself backward, pulling the telescope along while inspecting. In the inspection of tubes placed nearer the ground up to eye-level the operator can simply walk backward.

The telescope is adaptable to the inspection of other piping and tubes than still tubing. It can be easily employed in the inspection of reaction and soaking chambers, evaporators, and other large vessels not equipped with too much interior piping and fractionating devices. It is usable in the inspection of shell-and-tube exchangers, preheaters, condensers, and similar equipment, as well as in the inspection continuous coil condensers, coolers, etc., where the end connections permit ready removal. Straight transfer lines working under severe conditions, piping where corrosion is severe, acid and other chemical lines, and other lines where hazards are known to exist after continued service, can be readily inspected or photographed, at the regular plant inspection intervals, often to the end that dangerous pieces may be removed in time to eliminate the hazard.

Use of Instruments in Refining

V. R. CHADBOURNE
Electrical Engineer, Magnolia Petroleum Company

A NEW trade in the refining industry has developed in the past few years of rapid technical progress. It is that of the instrument man. The accompanying article interestingly discusses the duties of both the instrument man and the important instruments upon which successful operation hinges.

The efficient use of control and regulatory instruments in the refining industry depends upon a number of factors, of which the most important are careful selection, proper installation, efficient maintenance and intelligent interpretation.

COMPLEXITY of refining units both from the standpoint of construction and operation is continually increasing. Where formerly several separate units and separate operations were necessary to accomplish a desired result, it is now completed in one continuous action of well coordinated steps in one more or less complex unit.

Because of this complexity a great change has occurred in the trend of design and application of instruments. Where once a scattered number of mercury thermometers in conjunction with a few pressure gauges together with perhaps a displacement meter all located at points most accessible for installation but usually remote from the operator sufficed, the modern design of still and methods of operation require an amazing number of complicated devices. These devices must be capable of measuring accurately and controlling all sorts of flows, liquid or gas; temperatures, high or low; pressures of ranges long thought impossible. No longer can instruments be widely separated but rather the indicating or recording portions must be grouped at some central operating point.

Due to the great size of the operating units and to the tremendous forces to be controlled, human or manual control must be supplemented (in most instances superseded) by automatic control. These controls must be even more than automatic, they must be of types that may even be said to think. They must as far as possible forestall certain actions before they occur. Thus the operating staff must more and more rely and be dependent upon the instruments if they would operate successfully.

The instrument companies deserve praise for the manner in which they have met the demand for the greater use of instruments. With all the necessary complexity of remote types of instruments and intricate controls, they have continually striven with success for more rugged, more accurate and more reliable measuring devices.

The wide variety of types and the highly special nature of instruments then result in four problems in their successful use in industry.

1. Selection of proper instruments for the job.
2. Correct installation.
3. Proper maintenance.
4. Intelligent interpretation of records.

Selection of proper instruments requires understanding of types and intimate knowledge of processes. It should be done only by persons who know what certain devices can do and who also know what will be required of this device in controlling and measuring the results of a certain process.

RIGHT INSTRUMENT IN THE RIGHT PLACE

Too often the selection is done by some one in authority who is influenced more by the price than by other qualities more important. In a fairly modern refinery flow meters were purchased to measure the gasoline output from a cracking unit. This flow fluctuated badly and although it was desired to have the opertors calculate percentages hourly, yet some one with a mistaken economy viewpoint purchased recording flow meters without an integrator. The operators find it next to impossible to obtain hourly figures with any degree of accuracy. So the real object for which the meters were purchased has not been attained because some not thoroughly informed person thought a few dollars might be saved.

Although an instrument may be an excellent one, if installed to do work for which it is not designed it tends to bring discredit upon its manufacturer, the designer of the process and the operator of the equipment. Consequently the person who selects instruments should be thoroughly familiar with them and the conditions under which they must work.

Correct installation necessitates accurate information as to the function of the instrument and the results desired. Not only must the installation be correctly done from the mechanical standpoint, as covered by the instructions of the manufacturers, but also it must conform intelligently to local conditions.

But no matter with what care and at what expense

the instrument was selected and no matter how well it was installed, if improperly maintained the results obtained will be disappointing.

Proper maintenance may then be said to be of major importance in obtaining satisfactory results from instruments and indirectly from processes.

Maintenance like taxes, is always with us.

The complexity of the instruments, the fineness of their measurements and the delicacy of their parts require continuous examinations and readjustment. As these instruments become more expensive and complicated and as their measurements become of more value to the operators, it is essential that they be serviced only by skilled men.

The result of this is that a trade, new to the oil industry has arisen within the past few years. It is that of the instrument man. This is a trade that requires a man of a high class of intelligence.

THE INSTRUMENT MAN

The ideal instrument man would be one who was an excellent mechanic trained as a jeweler or watchmaker, with a fair electrical knowledge, familiar with process work and with plenty of good common sense. His mechanical knowledge is needed for the actual repairs, his electrical knowledge because many remote instruments transmit electrically, his process experience because it is necessary that he know what his instruments are trying to do, and his good common sense to reconcile a host of apparently conflicting circumstances. Of course such men are rare, but it is to be hoped that the future of instrument work is such as to attract educated mechanics to it.

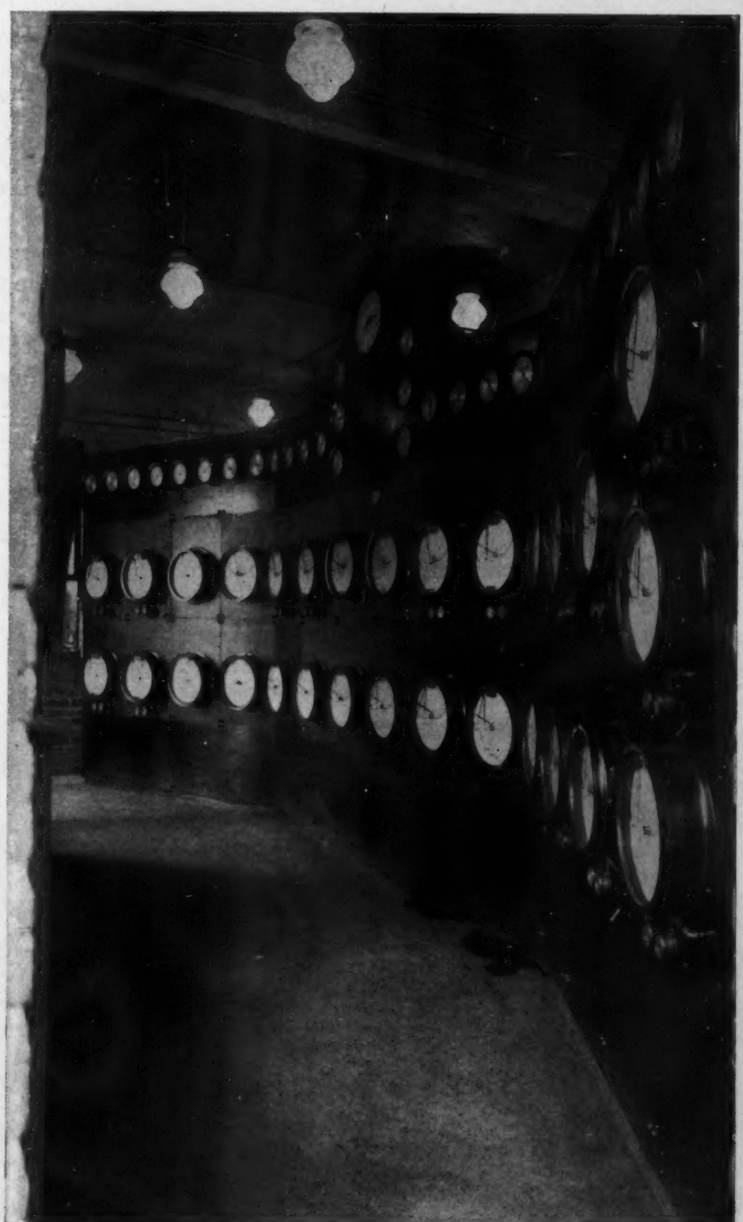
While a good instrument man is the basis on which to construct an efficient maintenance program, he must be equipped with suitable tools to do good work.

An instrument repair shop adapted to the variety of instruments of a medium sized refinery should include equipment for testing, checking and repairing pyrometers, flowmeters, thermometers and pressure gauges. The checking of prymoters and couples requires potentiometers, millivoltmeters, resistance boxes, battery boxes, standard couples, an electric furnace, small electric and gas welding outfits and a multiplicity of small special instrument repair tools. Flow meters must be checked against water columns. Both fixed and portable ones are desirable. Thermometers are checked against standards with a variable controlled steam chest for medium temperatures. Pressure gauges require a dead weight test gauge. There should also be a small drill press, buffer and bench lathe to facilitate the work.

It is also evident that a suitable stock of those parts which require frequent renewals must be carried on hand. In some cases it is advisable to carry enough spare instruments to permit one to be out of service for sometime when being overhauled.

Correct maintenance does not mean just repairs after a defect has occurred. Rather it is a systematic inspection in order to forestall outages of an essential instrument. So in addition to a good instrument man and a well equipped shop, a system of inspection and repairs must be laid out for best results.

Just how often certain equipment must be inspected



Control instrument panel for recovery and stabilization system in a large eastern refinery. Courtesy The Foxboro Company.

or cleaned depends upon several factors. Among these are its operating importance, the area it is in, (gassy or dusty) continuous operation, etc. Consequently, no fixed rule can be laid down; each plant is a study in itself.

For instance, in one plant a visual inspection of all cracking still instruments is made three times a day; pryometers are checked with potentiometers and flow meters zeroed once a week. Routine inspection of other instruments at other locations is much the same with the time between inspections depending upon the importance of the instruments to the operators.

Visual inspection tells the instrument man whether the instrument is acting as it normally should and warns him of approaching troubles. In this way, minor adjustments can be made to ward off serious repairs, the proper interpretation of its actions may anticipate trouble and prevent failure of an essential instrument thus avoiding the possibility of a costly shut down.

All instruments are brought to the shop from time to time as the units they serve are out of service, where they are inspected, cleaned and needed repairs are made.

In this way this plant has been very successful in keeping ahead of difficulties.

Finally, after a routine system has been worked out, together with an overhauling and repair schedule, it has been found that a history or record of checks, changes and repairs to be most helpful in tracing trouble.

This is done by means of a card index wherein each instrument is catalogued, showing when purchased, type, location, changes, repairs and any comments considered useful.

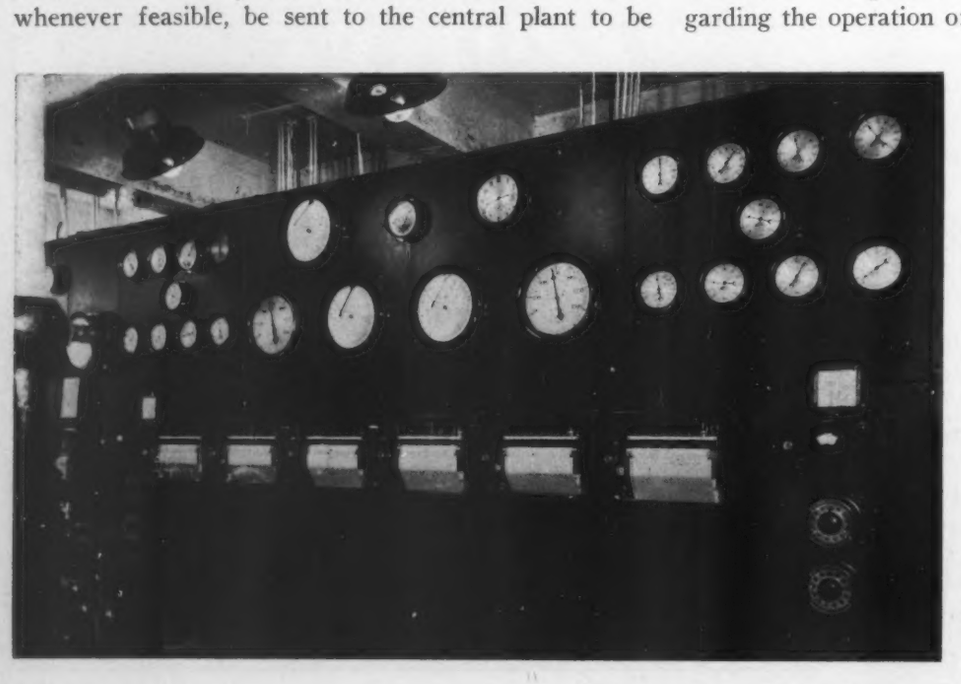
The present trend in refining is toward decentralization and results in numerous small plants. Obviously, such small plants cannot afford to carry an instrument specialist or to equip a shop as the one just mentioned.

The solution lies in maintaining a central plant having factory trained men and all necessary equipment. The men in the smaller plants would then from time to time whenever feasible, be sent to the central plant to be trained and instructed by the instrument experts there. In this way, a very efficient instrument maintenance force can be built up capable of making all inspections and minor repairs at the smaller plants with the major repairs being done at the central plant. In emergencies the better trained men from the central plant can be sent out to aid in the smaller ones.

An intelligent interpretation of the records is essential if worth while benefits are to be obtained from the use of instruments. A careful study of all records for corresponding periods on large refining units should be the duty of the operating as well as the engineering staff. The operators have the advantage of knowing just what is being done and thus should be able to obtain valuable information. Too often we find the operators content to run the unit as ordered without endeavoring to improve the operation from such a study.

Many of the good results from the proper selection of instruments and their proper maintenance may to a great extent be nullified unless there is cooperation between the operating and instrument departments. Often to a surprising degree neither side has the other's confidence as it should. Instruments are such new things and to the average operator so complicated that he looks upon them with suspicion and upon instrument men as merely mechanics without process knowledge. On his part the instrument man feels that when the operator refuses to believe an instrument which he knows has tested correctly that that is merely an alibi for his own ignorance of operating conditions.

Honesty and cooperation are absolutely essential on both sides because the operator must have confidence in the work of the instrument men and because the latter must have correct information to work successfully. Immediate and intelligent reporting of trouble, whether it be of an instrument or of operation, is beneficial to both parties. Instrument men should be instructed whenever time permits to talk with the operators regarding the operation of the unit. Invariably information is obtained to show why certain instruments are acting as they are. Exchange of information that either may have may be of great value to all concerned in tracing down trouble.



Control instrument panel board for cracking process service, Magnolia Petroleum Company, Beaumont, Texas, plant. Courtesy The Brown Instrument Company.

Remodeling and Modernization of Holmes-Manley Cracking Equipment

C. M. JOHNSON
Consulting Petroleum Engineer

THROUGH addition of heat exchangers, fractionating equipment, additional furnaces and changes in flow, scores of the original installations of various types of cracking processes throughout this country have been improved in efficiency. Much of this modernization work has been in progress during the past year or two. In the accompanying article, C. M. Johnson, Consulting Engineer, discusses the revamping and rehabilitation steps presently practiced in the modernization of the Holmes-Manley cracking installations.

THE Holmes-Manley process as generally covered in patents Nos. 1,583,973 and 1,585,355 and others, is characterized as follows: "The oil to be converted enters the system through a heating zone in which it is heated to or above cracking temperature and is then delivered to a second zone in which it undergoes distillation under pressure accompanied by substantial conversion, vapors unmixed with liquid products being drawn off from the stills above the liquid level, condensed and separated as condensate, while liquid products may be drawn off from a point below the liquid level in quantities or at a rate sufficient to maintain a substantial liquid body in the still. It shall not involve at any stage the maintenance of a relatively large body of oil at cracking temperature and pressure without continuous removal of the evolved vapors unmixed with liquid products from a point above the liquid level."

The process is primarily used for cracking gas oils and other clean overhead stocks. The owners prefer to operate upon prepared overhead charging stocks rather than upon heavier residual oils.

Flow sheet No. 1 is a typical example of the Holmes-Manley process briefly described as follows: Raw feed is first pumped through the reflux condenser thence to the preheater (pipe still) flowing downward through the economizer bank and preheater coils to vertical stills Nos. 1 and 2. At a predetermined point the "back-trap" from the bottom of the bubble tower is introduced into the preheater coil where it joins the raw feed. The four stills are held full of oil to a predetermined level in still No. 4; the oil passing from still No. 1 to No. 4 through high level flow lines. The stills are set within a suitable furnace and fired to maintain given temperatures, the vapors liberated being conveyed to the bubble tower, fractionated, and the gasoline removed overhead while the bottoms or "back trap" is reintroduced into the system. The residuum from the bottoms of the four stills is drawn off continuously or "shot" intermittently to the tar stripping plant where the pressure is released and distillation effected by means of the contained heat. Pressure on the system is maintained through the condenser.

The pipe still or preheater as it is commonly referred to was not designed as a cracking coil and the problem of revamping for advanced capacity was started at this point.

The original preheaters consisted of an economizer bank of tubes in the upper section of the preheater where flue gasses from the preheater coil and from the vertical still furnace were used against the raw feed. This coil consisted of 128 tubes in six rows, each 2.7 inches inside diameter, 3.5 inches outside diameter by 16 feet 2 inches long with an effective heating length of 14 feet 3 inches and surface of 1672 square feet.

The preheater coil was made up in 12 rows of 258 tubes of like size with an effective heating surface of 3370 square feet. Tubes in both economizer and preheater coil being arranged 22 and 21 tubes to the row.

Firing was accomplished through the use of venturi type burners using gas for fuel. A battery of these burners being in the front wall and generating temperatures under the first row of tubes in excess of 1700°F. This temperature was too high for the tubes and failures were common, more so as advanced rates of charge were tried.

The venturi type burners were removed and ex-

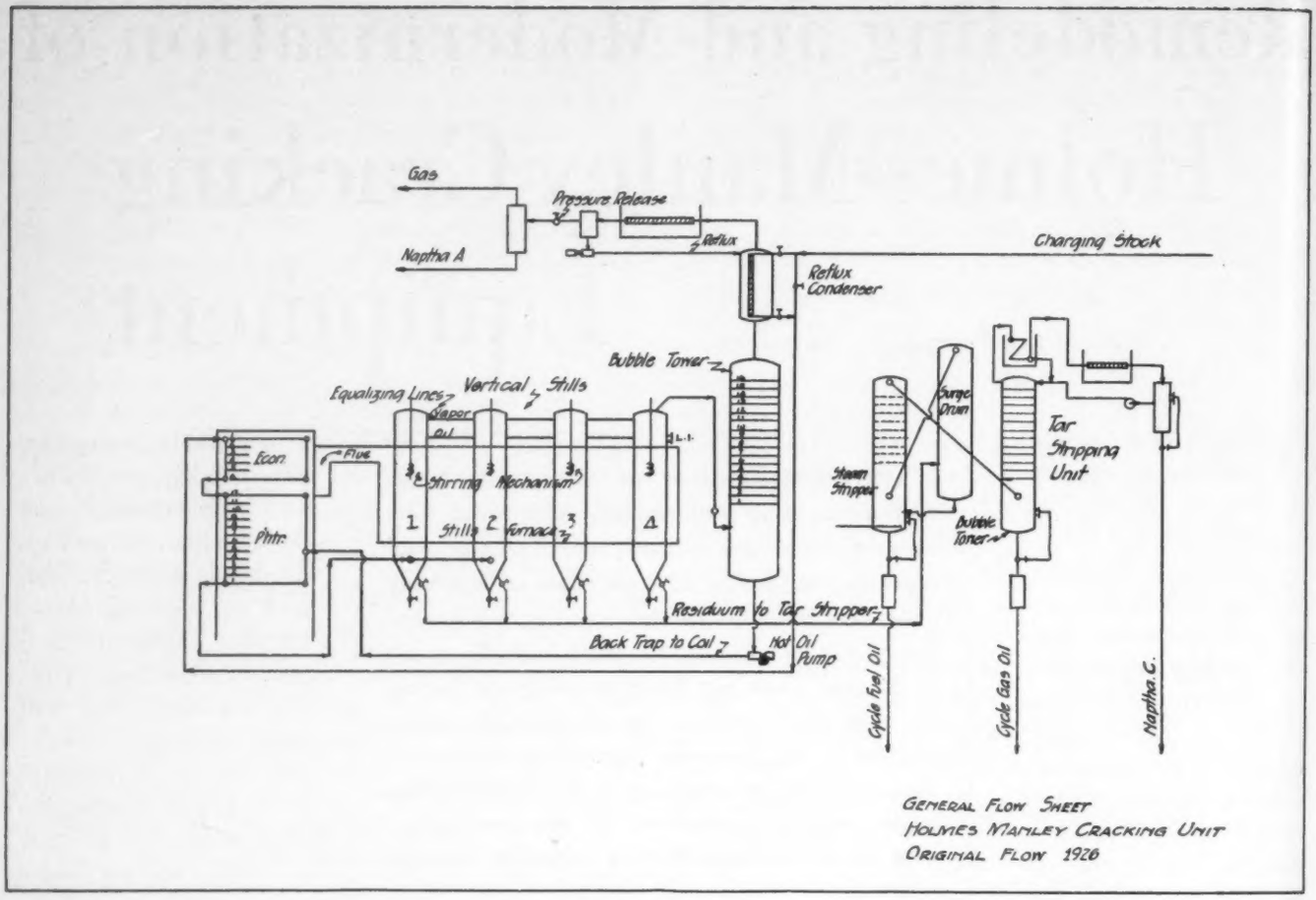


CHART NO. 1

cess air burners installed which improved this condition. At first the flames impinged upon the tubes at the rear wall and an inside Dutch oven, in effect, was built. After several trials as to placement of the walls of this oven a position was found where the distribution of heat was nearly equal in the four corners of the fire box under the tubes with temperatures rarely exceeding 1500°F. even while firing 20 to 22,000 cubic feet per hour of fuel gas at 100 per cent excess charging rate.

It was soon discovered however, that the ultimate yield of gasoline per barrel of raw feed had fallen off materially although the barrels of gasoline per month was increased through the advanced charge rate. Here then, was an economic problem—high ultimate yield or barrels of gasoline?

Harder firing of the vertical stills was resorted to which resulted in much shorter cycles of operation or time on stream with but little result in product.

Failing to secure satisfactory results from "temperature", means were now taken to provide the "time" element as well and side wall tubes were installed 16 on each side wall: each 3.5 inches inside diameter, 4.5 inches outside diameter by 16 feet 2 inches long providing an additional 537 square feet of surface with very satisfactory operating results.

With a constantly lowering market condition as well as the demand for higher quality it became imperative that steps be taken to still further increase production both in quantity and quality.

Pressure distillate was produced in place of naphtha or gasoline. Trays in the bubble tower were reduced from 32 to 11 and a vapor exchanger installed within the tower below the bottom tray and above the vapor line from the vertical stills. This added over 200°F. of heat to the charge which materially helped furnace conditions for advanced charging rates.

With the increase in charging rate the "back trap" pump pressures soon were in excess of pump capacity and it now became necessary to reduce the back pressure. After numerous trials it was found that splitting the flow of raw feed and "back trap" would accomplish this purpose without seriously interfering with the quality element.

Digressing, it is explained here that the raw feed entered the economizer bank and flowed downward successively through each row of tubes, out the bottom row and then down through one group of side wall tubes, across, and finally up through the other group of side wall tubes to the preheater outlet. The hot oil pump inlet was first pumped into row No. 5 joining the raw feed at that point. When the lower tower coils (vapor heat exchanger) were added the back trap was pumped into the third row as being a point of nearly equal temperature and the tower

coil by-pass valve was manipulated to control temperature of raw feed.

Careful experimentation finally showed that at a charging rate of 125 barrels per hour (nearly 200 per cent rating) the fourth row outlet for the raw feed was the proper point to split the flow. The back trap entered the third row, passing down through the second and first row and joining the raw feed at entrance to side wall tubes at within 5°F. of raw feed temperature. This split flow effected a dropping of pressure sufficiently to insure commercial operation at 200 per cent rating.

The scramble for octane number now made further development necessary. Other cracking processes resorted to higher temperatures (coil cracking), reforming, selected stocks and other such expediencies to meet market demands. The small company was now in a serious predicament to meet the competition offered by competing companies with more modern equipment.

Throughout the preceding developments a high liquid level was carried in the vertical stills. The licensor of the process in the meantime developed a low level operation to provide for vapor phase soaking.

Some units were fitted with coil cracking furnaces (De Florez, as described in Refiner, Vol. 11, No. 2, pp. 104-105), and others as per flow sheet No. 2; the salient points of which are as follows: Segregated coil cracking in which the dirty charging stock uses the economizer bank plus a portion of the preheater coil to secure a predetermined temperature before flashing in still No. 4 against the vapors from the cracking coil, the residuum from this flash being used as a quenching medium in the cracking coil transfer line to still No. 1. The prepared cracking stock ("back trap" as before referred to) using the balance of the preheater coil and side wall tubes.

This segregated coil cracking permitted high temperatures on the prepared stocks, giving results from the quality standpoint of a very high order and at a comparatively small revamping cost.

Flow sheet No. 3 combines topping and cracking operations into a single unit incorporating as it does the full utilization of residual heat for topping of crude; viscosity breaking of the top crude and selective coil cracking of clean charging stocks along with vapor-phase soaking. Topping is made possible because of the use of the vapor exchanger (lower tower coils); viscosity breaking at lower coil temperature and cracking at higher coil temperature because of the high quality of the charging stock.

Attention is called to the split of the cracking coil where in each engine of the twin simplex hot oil pump feeds its coil. This method materially reduces pressure drop through the coil and provides for a

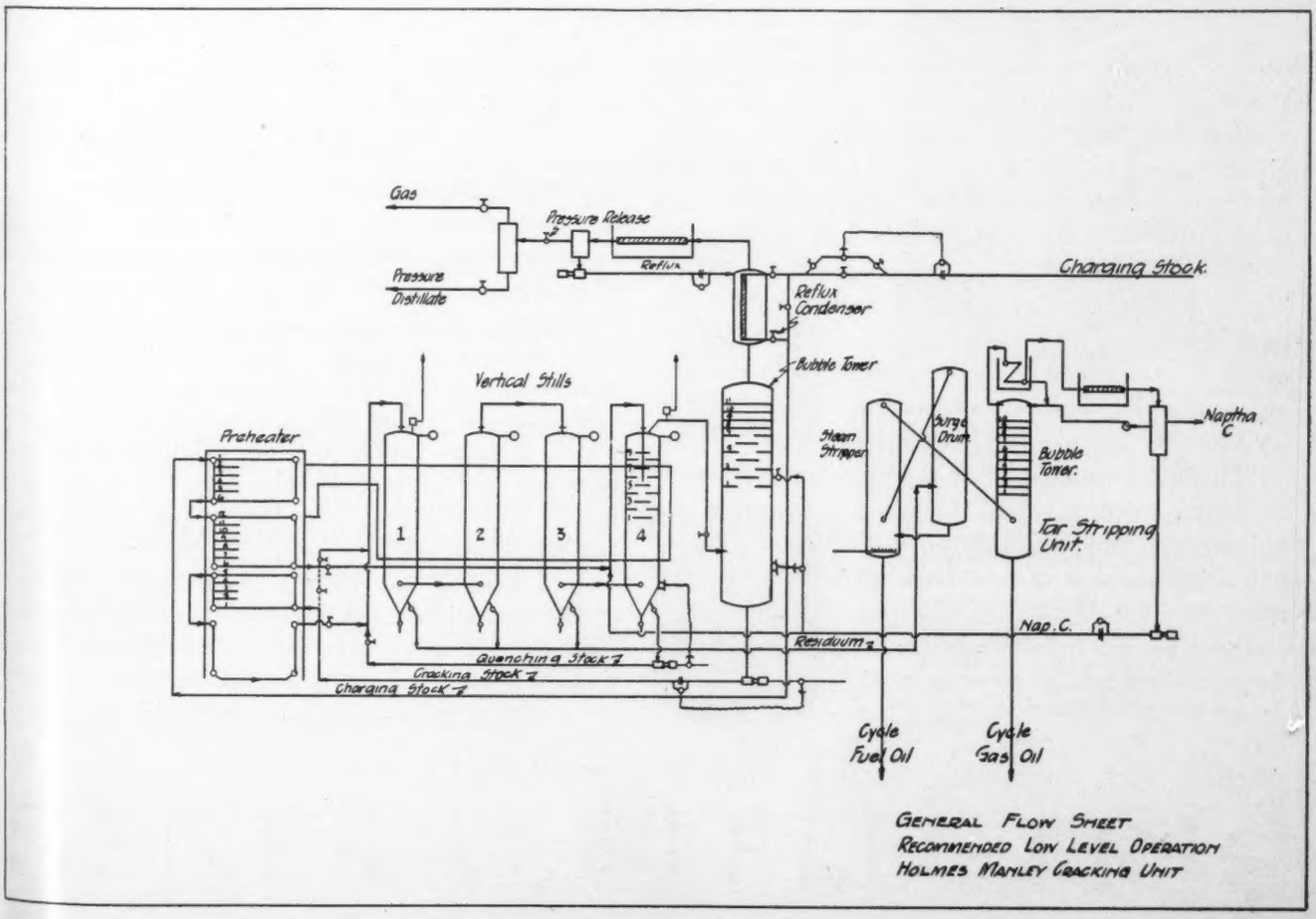


CHART NO. 2

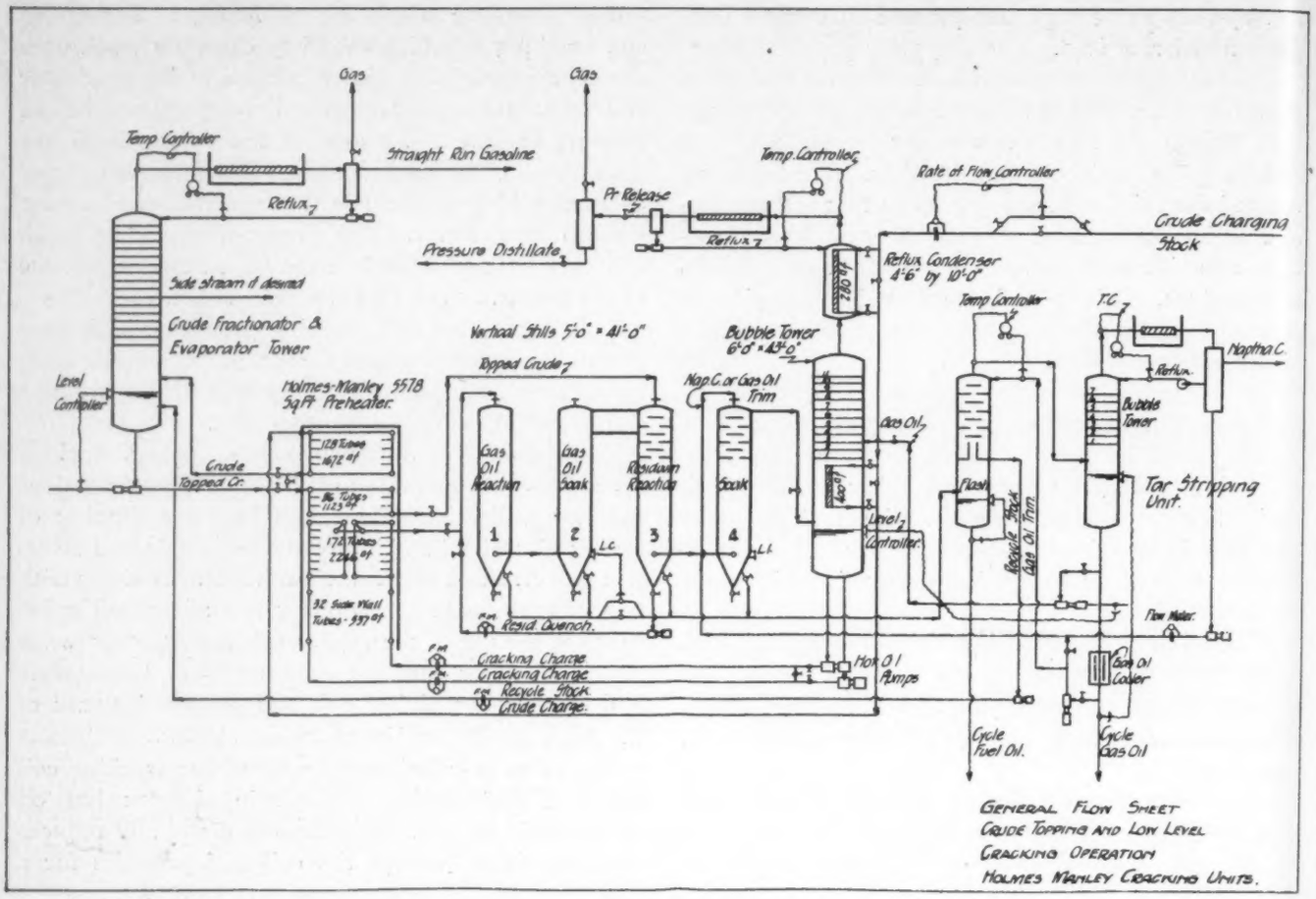


CHART NO. 3

maximum recycle ratio. Viscosity breaking operation flashes in still No. 3, the residuum becoming a quenching medium. This leaves still No. 4 as a combined vapor-phase soaking chamber which is trimmed with a wet reflux, thus insuring a perfectly clean cracking stock in the bottom of the bubble tower.

Perhaps the final step in the progressive revamping of Holmes-Manley cracking units would be to build a modern radiant heat furnace in front of the preheater. This new furnace would contain the cracking coil, while the preheater coil would be utilized for viscosity breaking and crude topping operations.

This final step is probably the ultimate in arrangement of equipment to suit today's manufacturing requirements combining the full utilization of the old unit with addition of new facilities to secure maximum results from any and all types of crude offered.

There are an infinite number of combinations of flow possible for the revamping of Holmes-Manley equipment to meet today's demands both as regards quality of product and cost of revamping.

All changes in revamping should be made with a view towards selective cracking of the individual stock for maximum yield of high quality products, unifying the various operations as much as possible to eliminate unnecessary steps which add to the cost of manufacturing.

The flow sheets all indicate a production of gasoline or pressure distillate presuming an after treatment of this overhead product. Vapor phase treating units may be added to eliminate this phase and which, combined with suitable stabilization and gas recovery system, would make a very complete unit for the production of a product in one complete operation.

It is obvious that while a single unit is described and illustrated here that the topping and tar stripping units as well as the treating and stabilization facilities could serve a battery of units as well.

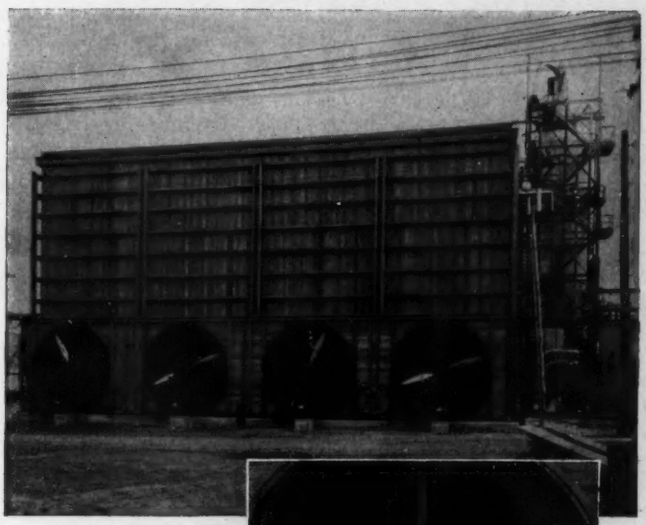
Protect your men and equipment with G-E Explosion-proof Motors and Control

THAT'S what a large eastern refinery did when it installed four G-E explosion-proof motors and control in a new cooling tower.

These motors and control give maximum protection to men and equipment. They operate out-of-doors, in an atmosphere containing explosive gases, and withstand rain, snow, dust, and dirt, with excellent maintenance records.

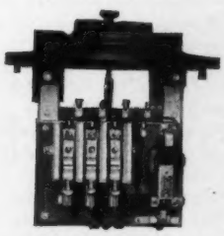
Note the new, compact G-E oil-immersed magnetic switch also used in this installation. It is both explosion-proof and corrosion-resisting. The special coils, contacts, and relay are completely immersed in oil, which protects them from corrosive gases. The entire switch is housed in a heavy, cast-iron, explosion-proof tank. Inspection of the switch is an unusually simple matter. The switch is mounted directly on the cover; for inspection, all that is necessary is merely to remove the cover bolts and lower the tank.

General Electric manufactures a complete line of electric equipment for the oil refinery—motors, control, transformers, switchgear, centrifugal compressors, turbines. In fact, you can buy everything you need from one dependable manufacturer. General Electric, Schenectady, N. Y. Write for a copy of our 50-page catalog, "Electric Equipment for Oil Refineries," GEA-1441.



Four G-E explosion-proof motors and controllers operating large fans in the cooling tower. These motors are tested, listed, and approved by the Underwriters' Laboratories for use in Class I, Group D, locations

A close-up view of one of the four G-E explosion-proof motors and controllers used in the above cooling tower. Note the simplicity and compactness of this installation



The new CR-7006 oil-immersed magnetic switch. Oil-immersed push-button stations of similar construction are available. General Electric also makes explosion-proof air-break controllers for either manual or magnetic operation. All G-E explosion-proof controllers are built to the standards of the Underwriters' Laboratories and are fully tested for use in Class I, Group D, locations. Write for a copy of our Bulletin GEA-1588A, on G-E oil-immersed, explosion-proof control

200-720H

GENERAL ELECTRIC

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical Composition and Reactions

The Catalytic Oxidation of Organic Compounds in the Vapor Phase. L. F. MAREK AND D. A. HAHN. *A.C.S. Monograph No. 61, published by Chemical Catalog Co., Inc., New York City;* pp. 486; $9.00.

The book deals fully with the catalytic oxidation of organic compounds and includes a valuable chapter on the phenomenon of knocking in explosion engines. The hydroxylation and peroxide theories and the application of the chain reaction mechanism are discussed. The many theories as to the cause of knocking and the anti-knock action of various materials are reviewed. Among the subjects covered in other chapters are the oxidation of the aromatic hydrocarbons, decomposition and oxidation of alcohols, synthesis of hydrocarbons and alcohols from water gas, the general theory of catalysis, and the preparation and mounting of catalysts.

Sulfur Compounds Derived from Petroleum. P. J. WIEZERICH, L. B. TURNER AND PER K. FROLICH. *Ind. Eng. Chem.* **25** (1933) pp. 295-6.

Mercaptans and other sulfur compounds are obtained at many refineries as a by-product of the recovery of spent caustic soda. Ordinarily the caustic is steamed, the steam condensed, and the mercaptans and other compounds burned. The authors have studied the mercaptans and their conversion to acetone dialkyl mercaltoles, thioethers, and disulfides. Thioethers upon oxidation yield sulfoxides, and, at higher temperature sulfones. Polysulfides can be prepared from mercaptans. Also, by oxidation, alkylsulfonic acids can be made from mercaptans. The properties of the several types of sulfur compounds are tabulated and their possible uses discussed.

Manufacture: Processes and Plants

Applied Colloid Chemistry. W. D. BANCROFT. *Book. McGraw Hill Pub. Co., N.Y.C.* (1932) pp. 544. $4.00.

This is the third edition of Dr. Bancroft's well known book on colloid chemistry. Although not treating specifically of the technique of petroleum refining, the work contains a wealth of material that is applicable to various phases of refining. The context is presented in a lively and interesting manner that is stimulating to the imagination.

Computation of Distillation Apparatus for Hydrocarbon Mixtures. E. W. THIELE AND R. L. GEDDES. *Ind. Eng. Chem.* **25** (1933) pp. 289.

The authors point out that the design of column equipment for the distillation of petroleum and petroleum products, insofar as the determination of the number of plates and reflux ratio is concerned, has been on an empirical basis. Decisions have been based on experience. The paper is a report on several years laboratory and theoretical work on this subject and is an important contribution to this field of knowledge. The authors state that this method is straight-forward, involves no further simplifying assumptions than that Raoult's law, or some modification, thereof, holds, and that plate efficiency is the same for old components, is worked out for solutions in which individual components are not distinguishable, and is applicable to fractionating operations of any complexity. The method is illustrated by applying it to a column with two plates above and one below the feed-point. The feed is pressure distillate. A side-stream steam stripper and a column with feed at two points are also analyzed in a similar manner.

Chemistry and Technology of Cracking. A. N. SACHANEN AND M. D. TILICHEEV, translated by A. A. Boehtlingk, D. F. Brown and K. T. Steik. *Book. Pub. by Chem Cat. Co., N.Y.C.* pp. 389, 1932. $8.00.

A review of the literature of the cracking art supplemented by a report of the investigations of the authors and their collaborators.

Cracking of Heavy Ends Left After the Distillation of Pressure Distillate. B. K. TARASOV AND G. N. SELEDZHIEV. *Neftyanoe Khozyaistvo*: **23** (1932) 177-9.

Fractions boiling above 200°C. and having (1) specific gravity of 0.824 and (2) 0.826 were subjected to repeated cracking (recycling) in an autoclave. (1) was cracked at 450°C. for 1 hr. 40 m. to 2 hrs. at 40 atm. pressure yielding gases (and losses) after one cracking operation 9.3%, fraction boiling below 200°C. 23.3%, at 200-300°C. 59.6%, above 300°C. 7.8%; after the first recycling 4.9, 13, 4, 36.5 and 4.8; after the second recycling 3.3, 7.8, 22.5, and 2.9; after the third recycling 1.6, 3.3,

HYDROGENATION

By **CARLETON ELLIS**

Starting with a clear account of the principles of hydrogenation catalysis, this book covers systematically the scientific work on the hydrogenation of individual organic compounds, and then presents exhaustively all the details of the industries themselves. The information in these pages has been compiled by the author over the many years of his career in this field. The researches, patents an inventions that have made him an outstanding authority on the subject of industrial hyrogenation tend to prove the value to you of this great book which has just been completed by the addition of new, hitherto unpublished information.

986 PAGES — 6 x 8½ CLOTH, ILLUSTRATED. PRICE — $15.00

Send order to

The GULF PUBLISHING COMPANY

P. O. Box 1307 Houston, Texas

You can't profit by making high octane gasoline if you lose most of the anti-knock value in treating

You don't have to lose it

Universal Inhibitor paralyzes the gum-forming molecules in the air and in the gasoline—keeps the anti-knock value all in and the gum all out

It costs less than treating by other methods and does a better job

Universal Oil Products Co
Chicago Illinois U S A

Dubbs Cracking Process
Owner and Licensor

LAGONDA CLEANERS

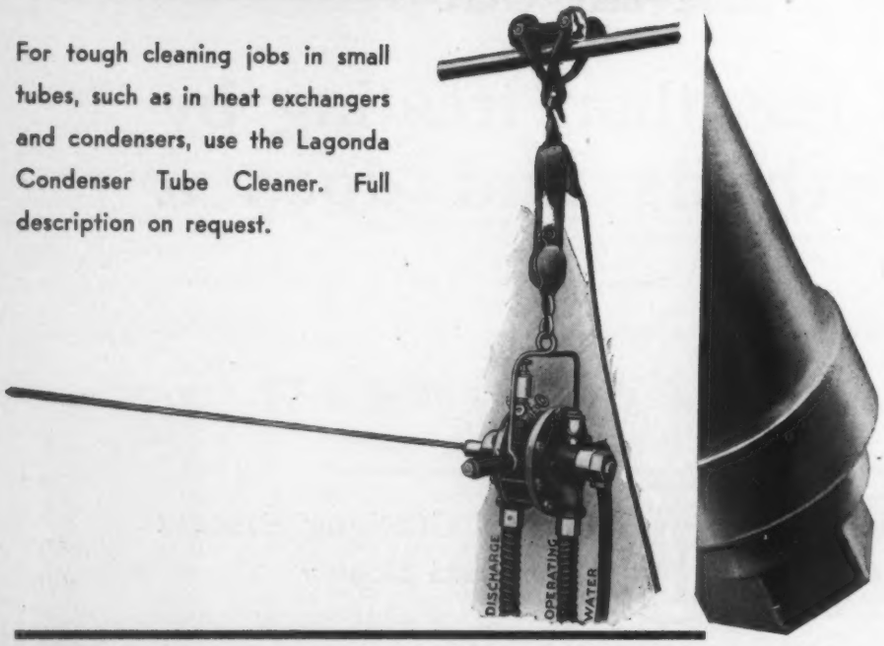
built from cutter head to hose coupling

for still cleaning

The toughest coke layer that ever fouled a still tube gives way before these sharp cutters, heat-treated to flinty hardness, and so assembled that they can be removed and replaced with ease. The powerful motor too, helps to cut costly minutes off the cleaning job.

Every detail of Lagonda Cleaners has been worked out in cooperation with still tube makers and users. Some of the latest developments may help you to cut still tube maintenance. Write for the latest bulletin.

For tough cleaning jobs in small tubes, such as in heat exchangers and condensers, use the Lagonda Condenser Tube Cleaner. Full description on request.



THE LAGONDA MANUFACTURING CO.
Springfield, Ohio
District Offices in Principal Cities
AN ELLIOTT COMPANY ORGANIZATION

X-1501

15.7 and 1.9 and; after the fourth recycling 1.1, 2.7, 10.6, and 1.3% respectively. (2) yielded after the first cracking operation 8.4% gases (and losses), 26.5% boiling below 200°C., 56.8% boiling at 200-300°C. and 8.00% above 300°C.; after the first recycling 6.6%, 13.2%, 31.8%, 5.2% respectively, all calculations being based on the original charge. Iodine numbers and total of aromatics and unsaturates produced in cracking are given. All samples were first treated with a solution of $CuSO_4$ + NaOH + NH_3. The gasolines were color stable after doctor treatment. Only one recycling operation is recommended when working on a commercial scale.

The Removal of Sulfur Compounds from Petroleum Distillates. H. N. HOLMES, A. L. ELDER AND N. BEEMAN. *J. Phys. Chem.* **36** (1932) pp. 2981-93.

Sulfur is removed by use of activated copper sulfide mounted on a gel. The gels were made by mixing dilute ferric chloride and sodium silicate, aging the gel, treating it with 9N sulfuric acid, and drying at 150-200°C. A white porous silica gel was also made. The white gel was soaked with 45% cupper sulfate at 60°C., dried in nitrogen or carbon dioxide, cooled to 0°C., saturated with H_2S gas, washed, and dried in nitrogen up to 200°C. To activate the CuS-silica gel it was heated at various temperatures from 200°C. to 500°C. The free sulfur from the decomposition of CuS to Cu_2S was evaporated. Copper sulfide proved to be superior to other sulfides in removing sulfur compounds. The gels can be repeatedly regenerated and reused. This method of treatment avoids loss of anti-knock value.

Cylinder Oils From Bottoms. L. A. GUKHMAN. *Rpts. Lubr. Oil Comm. U. S. S. R.* **:2** (1932) 173-177.

The preparation of cylinder oils from fuel oil-lubricating oil bottoms was accompanied by great losses through the treatment with H_2SO_4 and yielded a final product with a high Conradson carbon value and a poor color, whereas bottoms diluted with gas oil and treated with 96-98% H_2SO_4 yielded a far superior product. The treating procedures and the characteristics of the original stocks and the final products are given.

Preparing Bright Stocks and Automobile Oils from Baku Crudes. L. A. GUKHMAN. *Rpts. Lubr. Oil Comm. U.S. S.R.* **:2**, (1932) 143-8.

An attempt to prepare bright stocks from lubricating oil bottoms proved to be unpractical because of the high losses in refining. However, Vacuum-steam and vacuum distilled bottoms produced satisfactory bright stock distillates. The refining with H_2SO_4 and fullers earth proceeded without difficulty, and the total loss through refining was 25%. The pitch remaining as a residue from the distillation was of good quality. Dewaxing was effected by diluting the product with naphtha (1:1), chilling to —15° and filtering. The final product had a pour point of —5° to —8° and the yield, based on the original distillate, was 70%. The bright stocks were compounded with various proportions of machine oils whereby automobile oils of various viscosities, specific gravities, flash and pour points were obtained. Many data are given.

Preparing Bright Stocks from Emba Crude Oils. N. D. GRAMENITZKII. *Rpts. Lubr. Oil Comm. U.S.S.R.* **:2**, (1932) 109-16.

Emba lubricating oil distillates were treated with acid, neutralized with fullers earth and

This is the WEEK

YOU SHOULD ATTEND THE FAIR!

and the Industrial Marketing Conference!

Engineering Week
June 26-28

You're coming to the Fair of course!

Then come when you can enjoy these many business, educational and pleasure events *all in one week.* The Industrial Marketing Conference, Engineering Week — National Conventions of 19 technical societies, the Mid-West Power Show and the World's Fair, A Century of Progress.

The Century of Progress Industrial Marketing Conference, the eleventh annual convention of the National Industrial Advertisers Association, will treat the significant phases of the most important problem before industry today—increasing sales during a depression and a recovery.

Nationally prominent industrial executives worth hearing because of their success since 1930 will discuss market analysis, distribution, managing salesmen, sales promotion and advertising. There will be departmental meetings, clinical discussions of sales and advertising programs, panel displays and commercial exhibits.

The conference will be held at the perfectly appointed Medinah Athletic Club where you may enjoy the swimming pool, bowling, billiards, shooting gallery and other attractions. June 26 to 28. Don't miss it! Plan now! Write for details.

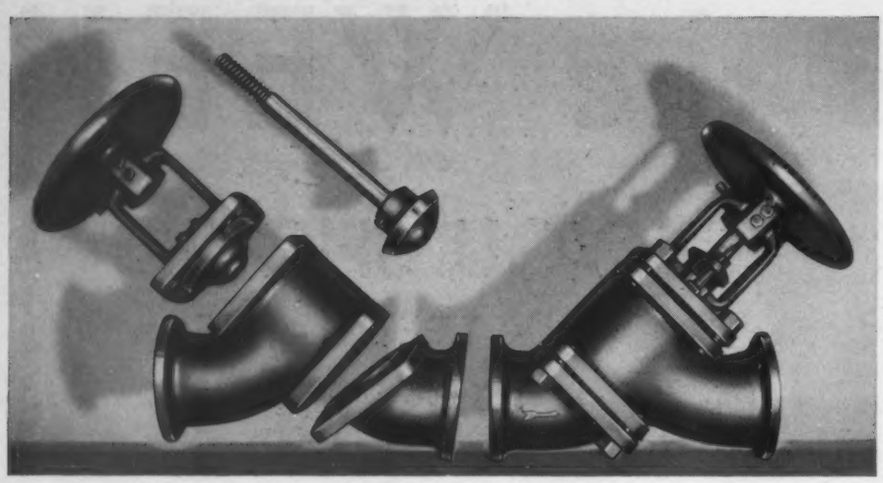
TIE THESE TOGETHER
IN ONE BIG WEEK—

National Marketing Conference
Engineering Week
Midwest Power Show
Century of Progress
Chicago, the Summer Resort

JUNE 26-28

NATIONAL INDUSTRIAL ADVERTISERS ASSOCIATION

National Headquarters — 537 S. Dearborn St.
CHICAGO



The 3-in R. S. Type Durimet Y-Valve is shown here assembled and with parts separated ready to assemble.

They Are Using More Because They Like Them

Twenty-two months is the record of a 3-inch Durimet "Y" Valve in service at one of the large refineries handling hot 30 deg. Be. sulphuric acid from "sludge cookers".

The record compares most favorably with a maximum of six weeks ever secured from any type or kind of metal used at this location previously.

As a result more Durimet "Y" Valves have been installed on batch acid drain lines.

Whatever your corrosive problem it will pay you to come to Duriron for suggestions. We are corrosion specialists.

THE DURIRON COMPANY, INC.

412 N. Findlay St., Dayton, Ohio

DURIMET

PREHEAT YOUR COMBUSTION AIR

with heat from the flue gases

Large fuel saving and better combustion from any fuel. 70 per cent heat recovery possible only with the continuous regenerative counterflow principle used exclusively in the Ljungstrom Air Preheater.

Write for literature.

800,000 Boiler hp. in service in the U. S. A.

AIR PREHEATER CORPORATION,
40 E. 34th St., New York

Sales and Engineering representatives in 25 other cities.

Ljungström AIR PREHEATER

CONTINUOUS REGENERATIVE COUNTERFLOW

treated with clay. Bright stocks of high quality and good V. I., which compared favorably with some of the American brands, were obtained. Some distillates showed a turbidity, which, however, did not affect their constants. This is explained as the result of the presence of small amounts of ceresine. The procedure is described in detail and complete data concerning the original stock, and the intermediate and the final products are given.

Contact Filtration. R. D. PETTY. *Rpts. Lubr. Oil Comm. U.S.S.R.* **:1,** (1930) 216-25.

Petty divides the clays in three groups: (a) Bentonites that are unsuitable for decolorization after mining, but are characterized by their high bleaching and neutralizing properties after activation. (b) Clays that had a subterranean treatment with CO_2 containing water loosing 50% of their efficiency. (c) Natural clays that bleach poorly but are efficient neutralizing media. The preparation of clays, their analysis, and their action on various petroleum products is given in detail as well as a layout of a treating plant for oil.

More Heads for Tanks and Heat Exchangers. C. O. SANDSTROM. *Chem. & Met. Eng.* **40** (1933) pp. 138-41.

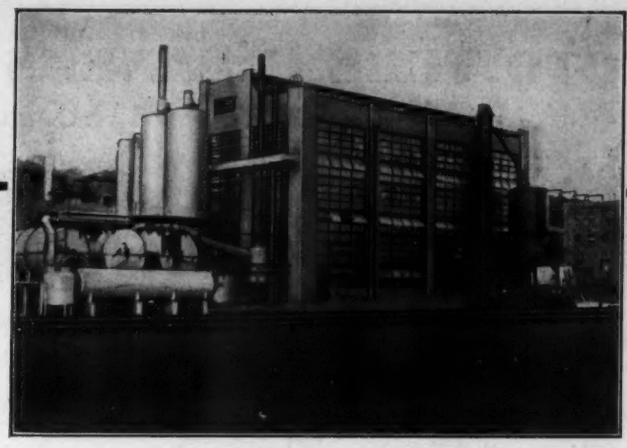
This is the third and last of a series of articles by the author on the general subject of heads for pressure vessels. The first article considered the usual heads, the second, head bolts, flanges and gaskets, and this one a new and cheaper head as well as cone bottoms and flat covers. The subject is treated in some detail and illustrated with concrete examples in which the ideas advanced are applied.

Avoiding Pitfalls in Pump Suction Systems. M. J. REED AND L. H. MORRISON. *Chem & Met. Eng.* **40** (1933) pp. 142-3.

The most vulnerable part of any pumping system is the suction. Piping must be air-tight, air pockets must be avoided, piping should slope continuously from pump to well, and off-set rather than concentric reducers should be used at the pump suctions. When pumping cold water at sea level there is available 34 feet of water head to force water from the well to the pump. This pressure must: (a) Raise the water a distance equal to the static suction lift, (b) overcome friction loss in suction piping, (c) overcome friction loss inside the pump, (d) provide the greatest velocity head, that is, velocity head at the point of smallest cross-section, (e) offset the vapor pressure of the water, liberation of dissolved air, and afford a margin to avoid cavitation. Although suction lifts as high as 24 feet have been reported for centrifugal pumps handling cold fresh water the greatest practical lift to count on is 20 feet. Of the remaining 14 feet of head the velocity head may absorb 1.5 feet, and vapor pressure 0.8 feet, or there will be approximately 12 feet head remaining to overcome pump friction, prevent air-bubble formation, and guard against cavitation. Variations from this average case are given and a few other liquids considered.

Eudurance Strength of Steels for Superheater Tubes. A. POMP AND W. ENDERS. *Mitt. Kaiser Wilhelm Inst. Eisenforsch* **14** (1932) pp. 261-9.

Two plain and five low-alloy steels (Ni, Mo, Mo-Cu, Cr-Mo, and Cu) were tested at 50°C. intervals from 350°C. to 600°. The steels alloyed with Cr. and Mo was superior to the others up to 550°C. However, at 600°C. the steels alloyed with Mo or Cu were best, es-



The new CHEMICO Sludge Conversion System (Hechenbleikner Process, Patents Pending) **produces clean strong 98% or 105% sulphuric acid direct from unseparated refinery acid sludge in an economical one-stage operation.**

Refinery executives are invited to inquire regarding the utilization of this new process, and an inspection of the large commercial installation illustrated above.

CHEMICAL CONSTRUCTION CORPORATION

Contracting Chemical Engineers

1112 South Boulevard
Charlotte, N. C.

New York Sales Office
535 Fifth Ave.

We specialize in plants for the manufacture and reclamation of sulphuric, nitric, phosphoric and other heavy acids and chemicals and fertilizers.

ROTO TUBE CLEANERS

built for Oil Still Tubes, 3″ I.D. *and up*

Roto Special 6-way Drill Head and Universal Joint.

Roto Air Driven Cleaner with Swing Frame Head attached.

Roto Combination Head and Universal Joint.

THE ROTO COMPANY

Sussex Avenue and Newark St., Newark, N. J.

It Keeps the DISCHARGE

Throttling Regulator

One of 40 regulators produced with skill and care by the pioneer gas regulator manufacturers of America. C-F products, in range and applications, encompass all practical requirements.

from Compressor

CONSTANT

When discharge pressure rises, suction is throttled. Thus discharge pressure cannot exceed a fixed point.

Built especially for this service, the C-F Throttling Regulator is entirely dependable in uniformity of action. With performance always punctual as well as precise, it assures ideal compressor operating conditions in so far as constant discharge control is concerned.

The Chaplin-Fulton Mfg. Company

Organized 1884—Oldest Builders of Gas Regulators in the Country. Regulators in all Sizes, from 1 inch to 24 inches; for all Service, 1 oz. up to 2,000 lbs. Pressure to Square Inch.

28-40 Penn Avenue **Pittsburgh, Pa.**

Representatives:

WESTCOTT & GREIS, Inc.
Sales and Service
Dallas—Tulsa

C. H. COLLINS
628 Dwight Bldg.
Kansas City, Mo.

HIMELBLAU, AGAZIM & CO.
228 N. La Salle St.
Chicago, Ill.

Or Any Jobber

pecially the latter. The physical properties of all the steels at all temperatures are tabulated.

Products: Properties, Utilization and Testing

Bituminous Emulsions for Use in Road Works. F. WILKINSON AND F. S. FORTY. *Book, Contractors Record, Ltd. London* (1932) pp. 395, 21s.

The use of bituminous emulsions in road construction has become firmly established. However, the literature on the subject has not been extensive. The present work is written in an effort to fill the gap. The practical sections of the book are an authoritative presentation of British procedure. The theoretical aspects of the subject are not handled so well.

Determination of Sulfur and Chlorine in Gasoline. C. WIRTH III AND M. J. STROSS. *Ind. Eng. Chem., Anal. Ed.*5 (1933) pp. 85-7.

Methods of chemical treatment involving the use of chlorine compounds, such as hypochlorites, zinc chloride, and the like, have made it necessary to determine the chlorine in gasoline. Also, the presence of chlorine compounds in gasoline interferes with the determination of sulfur by the lamp method. The apparent sulfur is higher than the actual sulfur. The method proposed by the authors comprises burning the gasoline in the Standard A.S.T.M. lamp with absorption of the gases in sodium carbonate solution, determination of total acidity resulting from sulfur and chlorine, and determination of chlorine by Mohr's procedure involving titration of chlorine with 0.1 N. silver nitrate with potassium chromate indicator. The results of numerous determinations of the sulfur and chlorine content of known solutions are reported and show that the accuracy of the method is well within the limits required of the A.S.T.M. lamp method.

Methods Used in the Investigation of the Chemical and the Fractional Composition of Cracked Gasoline. M. D. TILICHEEV AND M. P. MASINA. *Neftyanoe Khozyaistvo*: **23**, 161-9 (1932). *Second Article. (First article appeared in The Chemical Composition of Petroleum by* A. N. SAKHONOV, *Moscow-Petrograd* 1931 286-321).

The total of aromatics and unsaturates was determined by sulfonating the cracked gasoline followed by determination of the aromatics by the usual method after the removal of the unsaturates by bromination followed by distillation. The content of unsaturates was determined by difference. The method is claimed to be accurate within 1%. The content of aromatics in cracked gasoline does not change with the temperature provided the gasoline yield is unchanged. Thus gasoline from the Winkler-Koch cracking unit operated at 490°C., and that from the Jenkins cracking unit operated at 405°C., each contains 5-6% aromatics. The content of unsaturates increases and that of naphthenes decreases with rise of temperature. The heavier the cracking the higher the content of aromatics and naphthenes in the cracked gasoline. However, the average composition of the total of cracked gasolines from primary cracking and recycling operations is more or less constant. Aromatics are almost absent, but large quantities of naphthenes are obtained, when cracking pure paraffin hydrocarbons. The higher boiling cracked gasoline fractions are high in aromatics. This is particularly true for gasoline made by repeatedly recycling.

Methods Used in the Investigation of the Chemical and Fractional Compo-

sition of Cracked Gasolines. M. D. TILICHEEV, AND M. P. MASINA. *Khimicheskii Sostav Neftei i Neftyanuikh Productov by* A. N. SAKHANOV, *Moscow-Petrograd* 1931, 286-321 (First Article). (A collection of reports from the Groznuii Petroleum Institute. The research was carried out under the direction of A. M. Sakhanov).

Various methods for the determination of unsaturates and aromatics proposed by a number of workers are reviewed and the following procedure recommended. The total aromatics and unsaturates is determined by the Kattwinkel method (phosphoric acid and sulfuric acid). Aromatics and unsaturates are removed from another portion of cracked gasoline by treatment with 98% H_2SO_4 followed by distillation. The aniline points are also determined before and after treating the gasoline. Based on the determined amount of aromatics and unsaturates, the change of the aniline point after the removal of aromatics and unsaturates, and the coefficients for the aromatics and unsaturates, the amount of aromatics and the unsaturates is calculated. The experiments are reported in detail.

Apparatus and Methods for Precise Fractional-Distillation Analysis. II. W. J. PODBIELNIAK. *Ind. Eng. Chem. Anal. Ed.* **5** (1933) pp. 119-135.

This paper is a discussion of the findings of a laboratory study of the effect of several factors involved in precise distillation analysis. These factors are the compositions and distillation characteristics of the sample, the total time of distillation, regulations of distillation rate, reflux-ratio and pressure, column hold-up, reflux-condenser hold-up, nature of column packing, thermal insulation of the column, and general design of the entire apparatus. A column is described that has an entirely separate sleeve-like metal reflector-type vacuum jacket within which any one of several types of distilling tubes can be used. The column packing is a continuous wire spiral. Distillations require from one to several hours time. Numerous diagrams and data are given.

Apparatus for Precise High-Temperature Fractionation of Complex Liquid Mixtures. W. J. PODBIELNIAK. *Ind. Eng. Chem., and Ed.* **5** (1933) pp. 135-42.

A description of a precise laboratory fractionating apparatus for distilling complex solutions such as gasoline, crude petroleums, lubricating oils, and solvents is given. The vapor temperature can range from —190°C. to 300°C. and the pressure from 1 mm to 1000 mm. Methods of vapor temperature measurement, collection and measurement of distillate, changing receivers in a vacuum, and vacuum control are described. Numerous charts showing typical distillation results are given.

Handbook of Butane-Propane Gases. S. H. FINLEY, *Editor. Book, Western Gas, 124 W. Fourth St., Los Angeles, Cal.* pp. 279, (1932). $5.00.

The context of the book is contributed by experts in the respective fields. Data made available by the Standard Oil Company of California and the Philgas Company are included. The history of liquid fuels, beginning with Blaugas, is traced. Mechanical and engineering features concerned with the use of these gases is comprehensively covered. The last 50 pages of the book is a catalog of the equipment and appliances used in the manufacture, distribution, and utilization of the products.

WE EXTEND

A CORDIAL WELCOME

to all delegates and visitors attending the

OIL EQUIPMENT & ENGINEERING EXPOSITION

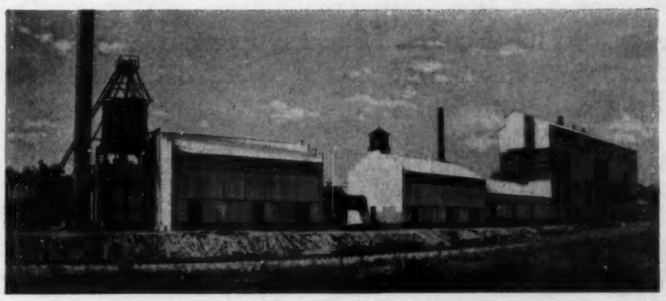
at Houston, Texas, May 22nd to 28th inclusive. We hope you will enjoy your stay in Houston as much as we will enjoy having you with us.

VISIT OUR BOOTH

and let us show you the various ways in which

PIONEER OYSTER-SHELL LIME

can serve you in your production and refining operations, and the many economies that can be effected by the proper use of this **better chemical lime.**



Plant of The Haden Lime Company, the first of its kind in the world.

THE HADEN LIME COMPANY

MFRS. OF PIONEER OYSTER SHELL LIME

1720 SHEPHERD STREET

HOUSTON-TEXAS

The REFINER and NATURAL GASOLINE MANUFACTURER
P. O. Box 2811 . . . Houston, Texas

Enter my name for subscription to The Refiner and Natural Gasoline Manufacturer for which you will find enclosed check for

☐$1.00 for One Year ☐*$2.00 for Two Years

Name .....

Street and No. .....

City and State .....

I am with the ..... **Company**

(Refinery Dept.)
(Natural Gas Dept.) and my position is .....
(Scratch One)

You can save yourself the trouble of sending another check one year hence by sending check for $2.00 for 2 years.

REFINERY ENGINEERS *turn to* NATIONAL SEAMLESS *for* CONDENSER PIPING

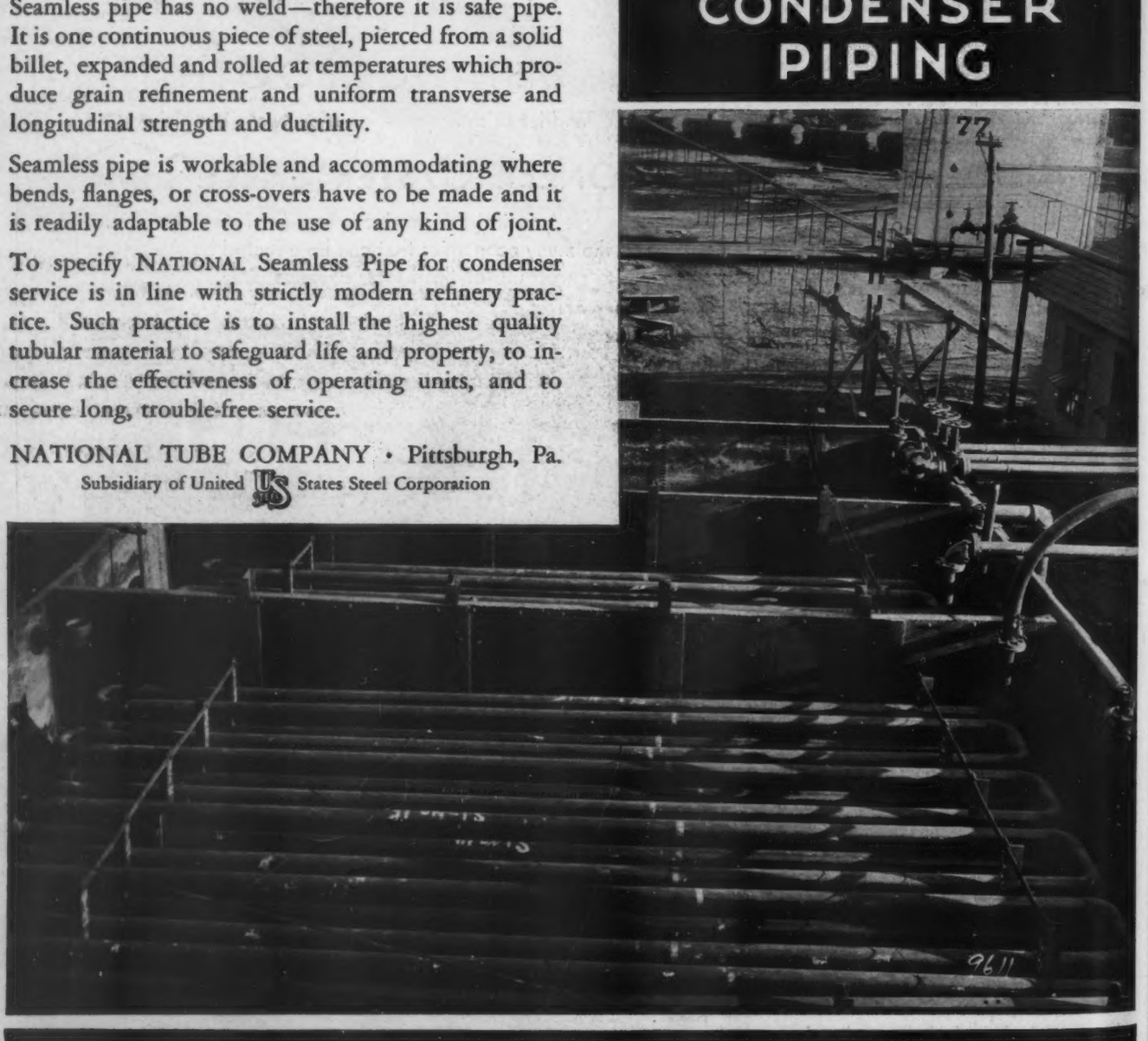
Following the adoption of Seamless Pipe for high pressure and high temperature lines, refinery engineers carry forward the "safety first" idea by adopting NATIONAL Seamless Pipe for condenser service. The possibility of split welds or open seams is thus entirely removed, as well as other uncertainties about pipe with a longitudinal line of weakness.

Seamless pipe has no weld—therefore it is safe pipe. It is one continuous piece of steel, pierced from a solid billet, expanded and rolled at temperatures which produce grain refinement and uniform transverse and longitudinal strength and ductility.

Seamless pipe is workable and accommodating where bends, flanges, or cross-overs have to be made and it is readily adaptable to the use of any kind of joint.

To specify NATIONAL Seamless Pipe for condenser service is in line with strictly modern refinery practice. Such practice is to install the highest quality tubular material to safeguard life and property, to increase the effectiveness of operating units, and to secure long, trouble-free service.

NATIONAL TUBE COMPANY · Pittsburgh, Pa.
Subsidiary of United States Steel Corporation



NATIONAL SEAMLESS
PIERCED FROM SOLID BILLETS-NO WELDS

THE MONTH IN REVIEW

Technical Program for A.P.I. Mid-Year Meet

AT the mid-year meeting of the American Petroleum Institute, Tulsa, May 17, 18 and 19 involving each of the three major branches of the industry, a program of particular interest and value to the refining division will be presented with eight papers scheduled, dealing with dewaxing of lubricating oil fractions and with cracking. The refining division also will meet in one joint session with the marketing division, devoting the time to such subjects as specification, oil burners, asphaltic products and fuels.

Like the refining division the production and marketing division will also have programs devoted especially to problems and subjects affecting their branches; and in addition, on Thursday afternoon, May 18, a general meeting will bring together the three different divisions. This is the only general session of the meeting.

Aside from the general and divisional sessions will be numerous meetings of special committees and of the board of directors, these sessions beginning Wednesday, May 17.

At the general meeting Thursday afternoon, C. B. Ames, president of the institute, will deliver his mid-year address and H. T. Klein, chairman of the American Petroleum Institute Industries committee, formed following the annual meeting at Houston last year, will then give a report on progress by his committee in combating gasoline tax evasion and in working with other agencies in opposition to increasing taxation burdens. Another feature of this session will be the release of the mid-year statistical survey and economic forecast of the refinery situation as prepared by the sub-committee on refinery statistics and economics which will be presented by Warren A. Sinshiemer, chairman.

At the first refining division session, with R. T. Haslam presiding, the following papers will be presented:

Centrifuge Dewaxing with Trichlorethylene—C. F. Pester and E. W. Luster, Standard Oil Development Company.

Solvent Dewaxing of Oils with Benzol and Acetone—F. X. Govers and G. R. Bryant, The Texas Company .

Dewaxing Oils in Propane Solution with Self-Refrigeration—W. H. Bahlke, R. N. Giles and C. E. Adams, Standard Oil Company (Indiana).

Laboratory Control of the Quality of Paraffin Distillate—L. L. Davis and D. S. Campbell, Continental Oil Company.

At the second session of the refining division, with R. E. Wilson presiding, the following discussions will be presented:

A Modern Experimental Cracking Unit—W. W. Gary and J. T. Ward, The M. W. Kellogg Company.

The Cracking of Mid-Continent Virgin Gas Oil Over a Wide Range of Temperatures and Pressures—P. C. Keith, Jr., J. T. Ward, and L. C. Rubin, Gasoline Products Company.

Developments in Naphtha-Reforming Practice for Octane-Number Improvement—H. W. Ferguson and E. J. Leroi, Humble Oil & Refining Company.

Cracking Light and Heavy Oils—Edwin F. Nelson and Gustav Egloff, Universal Oil Products Company.

The program for the joint session of the refining and marketing division, over which J. B. Rather will preside, is as follows:

The Range Oil Burner—Creator of a New Oil Market—L. F. Speare and C. B. Cooley, Gilbert & Barker Manufacturing Company.

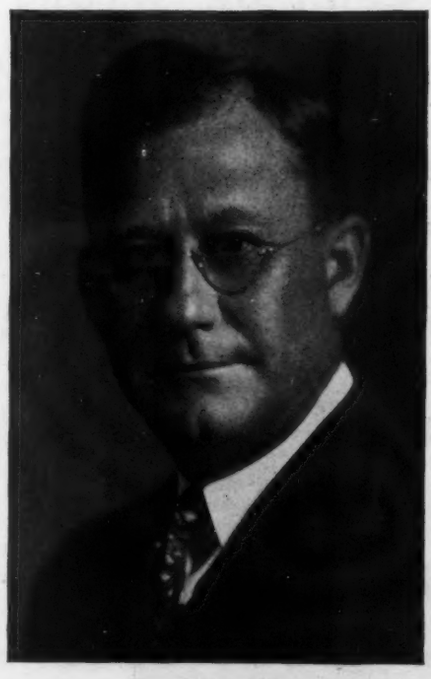
Specifications for Liquid Asphaltic Materials for Low-Cost Roads—E. F. Kelley, U. S. Bureau of Public Roads.

Liquid Aspaltic Road Materials from the Producer's Standpoint—Prevost Hubbard, The Asphalt Institute.

Ignition Quality of Diesel Fuels—A. G. Marshall, Shell Oil Company.

Bennette Elected President W.P.R.A.

HOWARD BENNETTE, who has been active head of Western Petroleum Refiners Association as managing director for the past 10 years, was elected president of the association at its annual meeting in Hot Springs early in April. He succeeds George D. Locke of Barnsdall Refineries, Inc. Mr. Bennette became secretary of the Texas-Louisiana-Arkansas division of the Mid-Continent Oil & Gas Association about 15 years ago, and in 1923 was elected secretary of Western Petroleum Refiners Association. Later he was made managing director and A. V. Bourque was elected secretary.



HOWARD BENNETTE

H. T. Ashton, Lubrite Refining Corporation; T. H. Barton, Lion Oil Refining Corporation; Roy B. Jones, Panhandle Refining Company, and L. R. Crawford, Producers & Refiners Corporation, were elected vice presidents at the recent meeting. A. V. Bourque was retained as secretary, H. K. Davis, as economist, and Fayette B. Dow, Washington, as counsel.

Gasoline Association Plans Interesting Program

THE program for the annual meeting of the Natural Gasoline Association of America at its meeting in Tulsa, May 15, 16 and 17, indicates that the meeting will be of more than usual interest and value to those in attendance.

The papers scheduled for presentation are both of a technical and economic nature. E. Buddrus, Phillips Petroleum Company, will discuss "Present Production and Future Trend of Mid-Continent Natural Gasoline." Another non-technical discussion is "Employee Relations in Industry," by C. W. Briles of Oklahoma A. & M. College.

The following technical papers will be presented:

"Comparison of Anti-Knock Characteristics of Vapor Recovery and Natural Gasoline Blends," H. M. Trimble, Phillips Petroleum Company.

"Study of Raoult's Law Equilibrium," S. S. Smith, Shell Petroleum Corporation.

"The Performance of Motor Fuels," Dr. G. G. Brown, University of Michigan.

"The Present Status of the Vapor Lock Problem," Dr. O. C. Bridgeman, H. S. White and F. B. Gary, Bureau of Standards, Washington, D. C.

Luncheon each day will be furnished by the Natural Gasoline Supply Men's Association, as will the annual dance in the Topaz Room, Mayo Hotel, at 9 p.m. Monday, May 15.

Industrial Lubrication Meeting, May 25 and 26

THE American Society of Mechanical Engineers will hold its second national lubrication engineering meeting at Pennsylvania State College, State College, Pa., May 25-26. The meeting is under the joint auspices of the college and the Lu-

brication Engineering Committee of the A.S.M.E. The following papers will be presented at the sessions:

Thursday, May 25

"Practical Interpretation of Lubricant Specifications," by J. G. O'Neill, U. S. Engineering Experiment Station, Annapolis, Md.

"Machine Design for Lubrication," by E. M. Barber and C. C. Davenport, Pennsylvania State College.

"Roll Neck Lubrication," by W. D. Hodson, Hodson Corp., Chicago.

"Lubricant Viscosity Standardization for Industrial Equipment," by Dr. A. E. Becker, Standard Oil Development Company, New York.

Friday, May 26

"Applications of Extreme Pressure Lubricants to the Lubrication of Industrial Machinery," by Dr. O. C. Bridgeman, U. S. Bureau of Standards.

"Problems of Lubricating Heavy-Duty Gears," by Austin Kuhns, Farrell-Birmingham Company, Buffalo, New York.

"Wire-Rope Lubrication: (a) Hemp Core, (b) Wire Strands, (c) Relubricating in the Fields," by A. J. Morgan, Roebling & Sons, Trenton, New Jersey.

"Discussion on Friction of Wire Ropes in Sheaves," by L. M. Tichvinsky, Westinghouse Electric & Manufacturing Company, E. Pittsburgh, Pennsylvania.

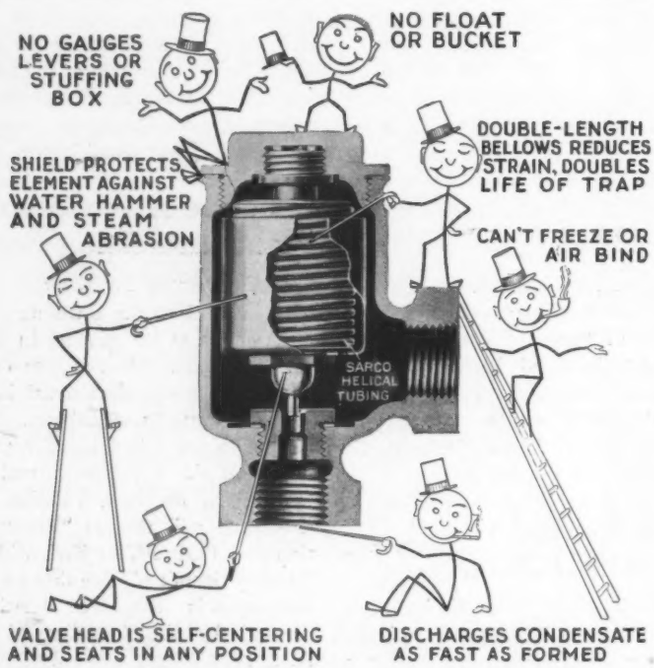
"Some Practical Factors Affecting Design and Operation of Bearings for Large Rotating Apparatus," by T. W. Gordon, General Electric Company, Schenectady, New York.

Lamason Heads Refiners In Louisiana-Arkansas

C. M. LAMASON, manager of refinery and bulk sales for Louisiana Oil Refining Corporation (Cities Service), was elected president of the Arkansas-Louisiana Refiners Association at its fourth annual meeting in Shreveport May 2. He succeeds D. P. Hamilton, president of Root Refining Company. Other officers elected by the association to serve for the ensuing year are Ben H. Gray, Spartan Refining Company, Shreveport, first vice president; J. E. Shatford, Ouachita Valley Refining Company, El Dorado, Arkansas, second vice president; E. F. Brakefield, Louisiana Oil Refining Corporation, treasurer, and Leon C. Grosjean, secretary.

C. M. LAMASON

In addition to the officers the following were elected to serve on the board of directors of the association: Col. T. H. Barton, Lion Oil Refining Company; D. P. Hamilton, Root Refining Company; J. H. Reideman, Crystal Oil Refining Corporation; F. R. Schneider, Simms Oil Company; D. B. Williams, Chalmette Petroleum Corporation; W. B. Hassett, Kettle Creek Refining Company; J. K. Mahoney, McMillan


NO GAUGES LEVERS OR STUFFING BOX
NO FLOAT OR BUCKET
DOUBLE-LENGTH BELLOWS REDUCES STRAIN, DOUBLES LIFE OF TRAP
SHIELD PROTECTS ELEMENT AGAINST WATER HAMMER AND STEAM ABRASION
CAN'T FREEZE OR AIR BIND
SARCO HELICAL TUBING
VALVE HEAD IS SELF-CENTERING AND SEATS IN ANY POSITION
DISCHARGES CONDENSATE AS FAST AS FORMED

A Million Buyers Can't Be Wrong

Even if the unrivaled value of Sarco Steam Trap could not be proved by comparison with other makes—even if its superiority could not be demonstrated by scores of outstanding good features—you could still buy the Sarco with complete confidence—for more than a million buyers can't be wrong!

FREE TRIAL — We have never asked anyone to accept our word for it that Sarco Traps will do the same work as big traps that cost several times the price and require an expensive pit or platform to install. Our policy is to let you try a Sarco Trap for 30 days and make it prove its superiority. If it doesn't sell itself, return it and there will be no charge.

To be sure that you are not overlooking something of real value, why not write NOW for Catalog S-95 and a Trap on Free Trial.

SARCO COMPANY, Inc.

183 MADISON AVE., NEW YORK, N. Y.

Branches in Principal Cities

Sarco Canada Limited, Federal Bldg., Toronto, Ont., Canada

Walker, Crosweller & Co., 20 Queen Elizabeth St., London, S. E. 1

SARCO STEAM TRAP

Petroleum Corporation, and George H. Hartung, Houston Oil Company.

The executive committee includes Mr. Lamason, chairman; Mr. Gray, Mr. Shatford, Mr. Hamilton and T. M. Martin. The manufacturing committee is composed of R. B. Pierce, chairman; R. T. Colquette, and J. J. Allison. Finance and budget committee members are C. M. Lamason, chairman; H. Canon and J. H. Riedeman.

The meeting heard an address by Howard Bennette, president of the Western Petroleum Refiners Association.

Doherty Research Gets Forward Patents

DOHERTY Research Company (Cities Service) and Dr. C. B. Forward, Urbana, Ohio, have formed a jointly owned company called Forward Process Company, which concern takes over the Forward patents and will handle development of the vapor-phase cracking process upon which Dr. Forward has been working for many years. All of the former stockholders of Oil Refining & Development Company formed by Dr. Forward are stockholders in the new concern. Doherty Research Company is now revamping a commercial cracking unit at the Pettys Island plant of the Crew-Levick Company (Cities Service subsidiary) and upon completion of this development the company will license the Forward process.

National Association Holds Semi-Annual Meet

NATIONAL Petroleum Association, at its thirtieth semi-annual meeting at Cleveland, April 20 and 21, devoted its first general session to the study of economic problems of industry. The remainder of the program was given over to technical problems. At the first session, E. M. Lyons, Tiona Refining Company, president of the association, stressed the facts that industry is in a period of great and fundamental changes and under a compulsion of events so strong that no man, or group of men, can prevent important changes taking place. He was followed by L. V. Nicholas, oil marketing counselor, Chicago, who talked on "The Cost of Meeting Competition and Tendered." John D. Gill, Atlantic Refining Company, spoke on the subject of "The Rules of the Game." W. T. Holliday, president, Standard Oil Company of Ohio, in his address, summarized the situation by stating that industry is seeing a new day and a new age, but that it has not changed its ideas or ways of thinking, and such a change is necessary.

J. A. Britton, Jr., Standard Oil Development Company, read a paper dealing with "Paraflow." James Haizlip, Shell Petroleum Corporation, aviation department, discussed "Yesterday and Today in American Aviation." H. L. Horning, president, Waukesha Motor Company, discussed "The Motor Octane Tests for Gasoline." There were also group meetings and conferences on fire prevention, safety, motor fuels, Pennsylvania lubricating oils, Mid-Continent lubricating oils, taxation of petroleum products and traffic and transportation.

Following the custom of past years the social event of the convention was the fellowship supper, held at the Hermit Club, April 20.

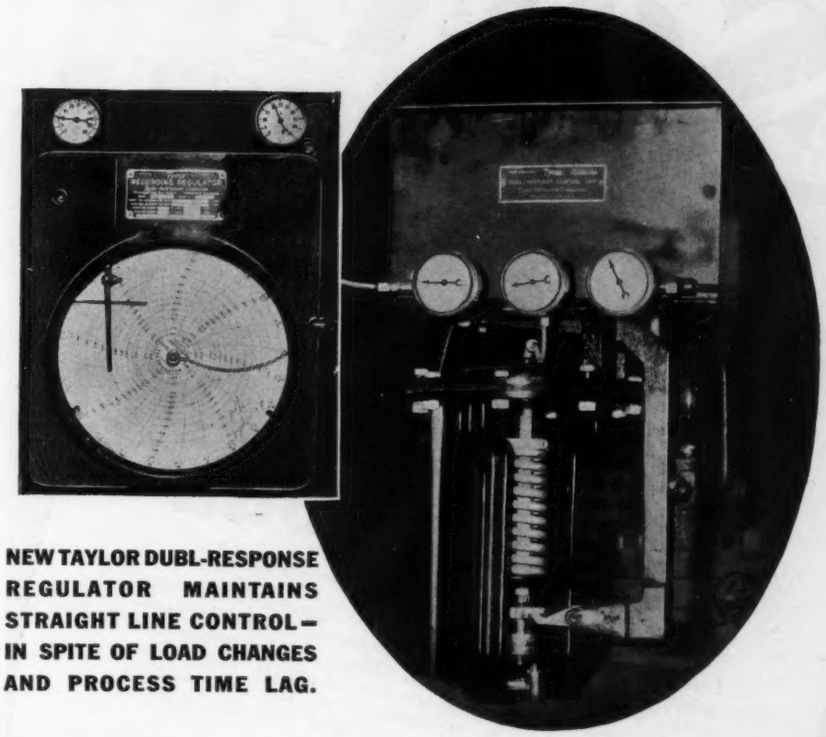
Heat Transmission Data Correlated

HEAT Transmission," by W. H. McAdams, professor of Chemical Engineering, Massachusetts Institute of Technology, is a remarkable compilation of heat transmission data prepared under the auspices of the Committee on Heat Transmission of the National Research Council.

Resulting from a wide study of the subject the author has given the most complete picture of the field of heat transmission yet published. The book is a textbook of principles and a source book of

Oil companies prove value of

NEW TEMPERATURE CONTROL



NEW TAYLOR DUBL-RESPONSE REGULATOR MAINTAINS STRAIGHT LINE CONTROL—IN SPITE OF LOAD CHANGES AND PROCESS TIME LAG.

TAYLOR presents a new instrument development in its Dubl-Response Regulator. This new unit, used with Taylor Recording Regulators and Evenaction Diaphragm Valves, overcomes stuffing-box friction and eliminates "sticky valve" troubles.

This instrument has proved its value on important installations. On the Pacific Coast a prominent oil company tested the Taylor Dubl-Response Regulator on the most difficult control job in one of its plants; namely, the fractionating tower top temperature of the pressure stills, requiring 4,000 to 9,000 gallons of reflux an hour depending upon the load. Previous operation of the tower had been a combination of automatic and hand control—sending a good portion of the reflux through a by-pass. The Dubl-Response Regulator took full control. The by-pass was closed. The results were so satisfactory, five more units were immediately ordered by this same oil company.

Let us tell you more and send you a new bulletin giving facts about the operation of this new development for the petroleum industry. Write to Taylor Instrument Companies, Rochester, N. Y.

Tycos Taylor

Indicating Recording • Controlling

TEMPERATURE *and* PRESSURE INSTRUMENTS

*The name Taylor now identifies our complete line of products, including Tycos instruments.

fundamental depth which will make it of real value to the student. It has the great quantity of data well digested and represented by equations and charts which will result in a maximum of utility to practicing engineers. Presentation of results of foreign investigators and correlation of these with American data should prove particularly welcome.

Conduction, radiation and convection is treated in the customary order with the major portion of the book dealing with convection. Since the most popular means of obtaining general equations for heat transfer in the past has been by dimensional analysis, the chapter on this subject is of considerable importance. The chapter on fluids in pipes is an outstanding contribution, and it considers both turbulent and stream-line flow. The chapter dealing with fluids outside pipes presents important graphical correlations for both forced flow and free convection. Chapters on condensing vapors and boiling liquids include much new information. The main emphasis of the book is on the correlation of data to yield formulas for heat transfer coefficients. The formulas are illustrated by individual examples.

Price of this work is $5.00.

SOLVAY
TRADE MARK REG. U. S. PAT. OFF.
PRODUCTS
58% Soda Ash
Caustic Soda
Solid—Flake—Ground—Liquid
Leading refiners depend on these products for the quality and uniformity which industry inevitably associates with the name Solvay. First in pioneering the development of American sources of alkali, The Solvay Process Company is recognized as the outstanding leader of its field—first in size and first in facilities for rendering efficient service.
Strategically located distributing points ensure prompt delivery of Solvay products with minimum transportation charges.
Write today for prices and full information.
Solvay Sales Corporation
Alkalies and Chemical Products Manufactured by
The Solvay Process Company
New York
61 Broadway

Fourteenth Exposition Of Chemical Industries

THE Fourteenth Exposition of the Chemical Industries will be held the week of December 4, 1933, occupying three floors of the Grand Central Palace, New York City. Over 150 companies have contracted for space at the exposition.

For some years now the chemical expositions have added new sections in line with the advancing interests of exhibitors and audience and in keeping with current trends. This year the brewing industries section will be added. Already a section devoted to natural resources and raw materials, chemicals and chemical products, and mechanical handling of materials in plants have been added. Laboratory equipment and supplies and plant equipment, constitute two separate sections. Instruments of precision is another division, as is the one devoted to containers and packaging. In 1931 a section devoted to plastics and molded products was added. With the exposition eight months away there is plenty of time for the building of interesting exhibits, some of which, this year, are laid out to be particularly practical and appealing. Generally speaking, the recent leasing of exhibit space has been by firms wishing now to be assured of the best possible locations within the amounts of their appropriations.

Carbon Black Production Continues to Decrease

FOR the second successive year production of carbon black in the United States has decreased. Production in 1932 amounted to 242,700,000 pounds. This, according to Bureau of Mines Mineral Market Report 194, was a decrease of 38,207,000 pounds, or 14 per cent less than production in 1931.

All of the major producing districts reported less production in 1932 with the largest percentage decrease in Louisiana. Production in the 23 plants of the Texas Panhandle in 1932 totaled 177,369,000 pounds, which, though a decrease of 10 per cent from 1931, was equivalent to 73 per cent of the country's output. In 1930 and 1931 this ratio was 67 and 70, respectively, indicating a continued centralization of the industry in the Texas Panhandle. Utah and Montana dropped out of the producing column in 1932, leaving only Texas, Louisiana, Oklahoma, and Wyoming as producers.

The situation as to carbon-black stocks underwent a radical change in 1932, when, for the first year since 1928, there was a net withdrawal from storage. Stocks held by manufacturers on December 31, 1932, totaled 257,998,000 pounds, or 23,669,000 pounds less than stocks on hand January 1.

In spite of an improved statistical position in 1932, prices of carbon black con-

tinued to sink to new low levels. The average wholesale selling price in 1932 was 2.75 cents per pound, compared with an average of 3.07 cents in 1931.

The yield of carbon black in 1932 remained unchanged at 1.44 pounds per thousand cubic feet of gas treated. At this yield the total indicated consumption of natural gas at carbon-black plants in 1932 was 168,237,000,000 cubic feet.

The United Kingdom continued to be the leading carbon-black customer, followed by France and Germany. Exports to the United Kingdom declined 1,221,000 pounds in 1932 but exports to Germany were 1,802,000 pounds higher than in 1931. Exports to Australia showed the largest increase in 1932, both quantitatively and relatively.

Synthetic Petroleum Products

AT the joint meeting of the Society of Chemical Industry, the American Chemical Society, the Electrochemical Society and the Societe de Chimie Industrielle held May 12 at the Chemists' Club, 52 East 41st Street, New York City, Dr. Gustav Egloff of the Universal Oil Products Company, Chicago, presented a paper entitled "Synthetic Petroleum Products," dealing with the contributions chemical research has made to the refining of crude oil in the last few years.

With the advent of the motor car and the simultaneous development of gas and electricity, gasoline has become of chief importance. Further developments in the automotive industry in recent years, as well as in the airplane, electrical, machine, power plant, road building, solvent and alcohol industries, have been accompanied by intensive research in the oil industry, not only to conserve crude oil but to produce new products, cut the costs of present ones and develop new methods of refining.

Although there have been predictions of an eventual oil shortage, Dr. Egloff stated that there was evidence at present of a supply to last for at least a century and the number or extent of oil pools yet to be discovered cannot be estimated. In addition, in the last 20 years chemists have shown how to increase the yield of gasoline from crude oil more than 300 per cent, as well as how to greatly improve its quality. By the use of the cracking process it is estimated that over three billion barrels of crude oil have been conserved in the last six years alone.

The speeds which automobiles, airplanes and motorboats have attained have thrown a heavy burden on the oil industry to provide proper lubricants. More progress has been made in the manufacture of lubricating oils in the last few years than in the preceding 30. New extreme-pressure lubricants have been developed made up of blends of petroleum oils, saponifiable oils and sulfur. Crude oils for lubricants are carefully selected and improvements in the refining process have been made for this particular demand. Synthetic lubricating oils have been developed by hydrogenation. Polymerization by aluminum chloride of oil produced by cracking also yields lubricants.

The oil industry can produce over a billion gallons of alcohol a year from cracked gasses. At the present time over four million gallons of ethyl alcohol are being produced yearly from this source, at a price competitive with alcohol produced from grain or molasses. If the economic situation demanded, the oil industry could supply the United States with alcohols. Enormous volumes of oil are available which could be cracked into unsaturated hydrocarbons and converted into alcohols in direct competition with alcohols from agricultural products.

Other synthetic products from the petroleum industry include such materials as asphalt, road oils, fuel oils, solvents and resins.

"Q" Compound for Motor Fuels Again Offered

ETHYL Gasoline Corporation last month revived its proposal to permit refiners to add "Ethyl" to regular grades

STAINLESS AND HEAT RESISTING ARC WELDING

MAURATH · ELECTRODES · IN WORLD WIDE USE

ELECTRODES

If you weld stainless alloys buy from the oldest company producing Alloy Electrodes exclusively and serving the world's leading steel producers and users.

All popular analyses of chrome and chrome-nickel electrodes carried in stock.

The world's leading oil refineries use Maurath Processed Stainless Electrodes for welding new equipment and combating corrosion in its various phases and stand the most drastic service.

Maurath, Inc.

3141 Croton Ave., Cleveland, Ohio

INSTANT
Knowledge of your
FLOW CONDITIONS
with the

M J L
FLOW INDICATOR

Close Hook-up Type

Calibrated in any units you desire for *direct reading* of rate of flow in lines carrying water, oils, chemicals, air, gas and steam—pressures to 2000 lbs.

Two types—"Close" and "Remote" Hook-up.

Write for Bulletin 208, with interesting technical details . . . *No obligation.*

MOREY & JONES, Ltd.
Manufacturing Engineers
924 So. Hemlock St., Los Angeles, Cal.
Division R

PETROLEUM DICTIONARY
By HOLLIS P. PORTER
Member of American Society of Mechanical Engineers, American Petroleum Institute

This work grew out of a demand for some source of definition for the terms used by the petroleum industry. It contains 3,000 definitions of words used constantly by all phases of the petroleum industry. It was published early in 1931 and has found its way into engineering departments, legal departments and land departments of producing concerns, as well as to the desks of executives of the petroleum industry.

Manufacturers also find it valuable for reference. Advertising agencies find it a valuable addition to the library.

234 Pages, 6 x 9, cloth bound, Price Postpaid, $3.00.

Send order to

THE GULF PUBLISHING COMPANY
P. O. Box 2811, Houston, Texas

of motor fuel and beginning June 1 refiners will be licensed to sell a leaded second grade of gasoline.

This "Q" brand of anti-knock compound will be offered to Ethyl licensees and will be sold to licensed jobbers. The compound can be mixed only with gasoline selling at a price next highest to Ethyl and it may be used by the refiner in only a portion of his supply of regular gasoline. The price of the compound is given as 0.35 per cc. plus a gallonage charge of 0.05. The contract states that a minimum of 0.3 cc. or a maximum of 1.5 cc. per gallon may be used. In regard to specifications, these must meet those of the regular Ethyl gasoline. The maximum knock rating of the finished or leaded gasoline will be 70 octane number by the C.F.R. Motor Method, but this maximum may be increased on proper authorization. Any color except red may be used to identify the new fuel and the Ethyl trade name or trade-mark may not be used in advertising or selling the product.

In many ways the new proposal is similar to that made by the company in 1931 and later withdrawn after meeting with much opposition by refiners. The new proposal does not include a minimum octane rating such as was suggested before, but leaves this to the refiner to decide upon as influenced by competitive conditions.

▼ PLANT ACTIVITIES ▼

Lube Plant: Champlin Refining Company, Enid, Oklahoma, is enlarging lubricating oil department and materials are being delivered for installation.

Refinery: McGeehee & Company, Dallas, Texas, contract to Ampco Engineering Company, Dallas, for construction of 4000-barrel skimming plant one mile north of Kilgore, East Texas field.

Purchase: O'Bar Refining Company has sold its 500-barrel skimming plant to C. B. Mitchell, Coleman, Texas.

Receivership: Simrall Refining Corporation of Canada, Ltd., owning refinery at Amherstburg, Ontario, completed in May, last year, has gone into bankruptcy, Guarantee Trust Company, of Windsor, trustee.

Gasoline Plant: Imperial Oil, Ltd., is completing erection of Turner Valley Field natural gasoline extraction plant to process gas from Royalite Oil Company and other Imperial subsidiaries operating in the area.

Operating: Shell Oil Company of Canada has started operating new refinery at Montreal East, Quebec, at 3750 barrels. Capacity is to be increased to 5000 barrels and lubricating oil and grease production departments added.

Gasoline Plant: Independent Oil and Gas Producers Association and independent operators in the Canadian Turner Valley field have been negotiating for the erection of a 50,000,000 cubic feet gasoline plant and carbon black plant in connection, planned to cost about $500,000 if joint program culminates.

Enlarging: Gillette Refining Company, Gillette, Wyoming, George E. Keisling, owner, is doubling capacity of its small refinery and installing loading rack.

Refinery: Bales Oil Trust and D. L. MacDonald, Worland, Wyoming, converting old alfalfa mill to a small skimming plant to run Hidden Dome crude.

Refinery: Stephens Refining Company, organized by W. B. Hassett, president and H. M. Gilbert, superintendent, has purchased from receiver of Kettle Creek Refining Company, equipment for 400-barrel skimming plant which is being erected at Stephens, Arkansas.

Enlarging: Lake Refining Company, Gladewater, East Texas field, adding still to increase capacity to 700 barrels daily.

Refinery: Upshur Refinery, Inc., erecting 250-barrel skimming plan near Gladewater, East Texas field, which is headquarters. Principle stockholders are P. B. Goodwin, H. T. Melton and I. M. Moore.

Rebuilding: Gregg Refining Company, Gladewater, East Texas field, destroyed by fire April 30, announces plans for rebuilding.

Operating: Danciger Refineries, Inc., is the name under which Petroleum Refractionating Corporation will operate 10,000-barrel skimming plant at Bodie, near Longview, East Texas field. (Formerly Slack Petroleum Company).

Dewaxing: Socony-Vacuum Corporation is reported planning early installation of De Laval S-N- Tri-Process (Trichlorethylene) for dewaxing lubricating oil fractions at one of the Vacuum Oil Company refineries.

Gasoline Plant: Gregg-Tex Gasoline Corporation has been organized by H. R. Dickerson, formerly vice president Arkansas Fuel Company and E. E. Jones, formerly general superintendent of gasoline plants for Arkansas Natural Gas Corporation, and associates, and will build a 10,000,000 cubic foot hot column type absorption gasoline plant in the northeastern portion of the East Texas field. Company address is 1025 Slattery Building, Shreveport, Louisiana.

Cracking: Crew Levick Company, Pettys Island plant, is modifying cracking process to operate as a vapor phase cracking system under the Forward patents. Forward Process Company was recently formed by Doherty Research Company and Dr. C. B. Forward, to license the Forward process upon completion of commercial development.

Gasoline Plant: .The Arkansas-Louisiana Pipe Line Company (Cities Service) is erecting a small absorption gasoline plant in the Rodessa gas field, Northern Caddo Parish, Louisiana, planning to operate May 15. Capacity reported 8000 gallons daily. Plant is steam operated and Southwestern Engineering Corporation equipment.

Improvements: Caminol Oil Company, Hanford, California, installing large fractionator for making gas, oil and kerosene fractions. Contract to Southwestern Engineering Corporation.

Acquisition: Oil Refineries, Inc., recently organized by M. J. Grogan, B. P. Crittenden and associates of Shreveport and New York, has ac-

quired the 3000-barrel refinery of Rusk Refining Company, Overton, East Texas field. Reports state a cracking unit will be added.

Acquisition: Sloan & Zook Refining Company, newly organized subsidiary of Sloan & Zook Company, has purchased the 1000-barrel refinery of Swan-Finch Oil Corporation at Warren, Pennsylvania, and will add a new tube still and overhaul the plant. R. T. Zook, president; W. J. Sloan, vice president and treasurer, and C. T. Rickerson, secretary.

Improvements: Soc. Italo-Americana del Petrolio, Italian subsidiary of Standard Oil Company (New Jersey), has completed technical reorganization of Soc. Petrolifera Italiana, S. A., and plans building a larger refinery at Fornovo Taro, Parma, according to Petroleum World, London, England.

Refinery: Federated Oil Consumers, Ltd., D. Austin Lane, Calgary, Alta., Canada, plans construction of a refinery. Estimated cost, $75,000.

Liquefied Gas Plants: Sun Oil Company at its Toledo, Ohio, Yale, Oklahoma, and Marcus Hook, Pennsylvania refineries installing plants for production of liquefied petroleum gases.

Improvements: Triangle Refining Company, Venice, California, contract to Southwestern Engineering Corporation for improvements to include installation to two large high pressure heat exchangers.

Cracking: Cosden interests which recently purchased properties of Cosden Oil Company, have given contract to Winkler-Koch Engineering Company for modernization of the Big Springs, Texas, refinery, including combination skimming and cracking facilities.

Operating: Homan Refining Company, which recently purchased Hercules Gasoline Company refinery, Vernon, California, has started operating the skimming and Jenkins cracking plant.

Repairs: Gulf Refining Company, Nevill Island, near Pittsburgh, will repair refinery and stills recently damaged by fire.

Operating: Crescent Refinery, Inc., Holdenville, Oklahoma, operating at 1000 barrels daily. Plant built by Victor H. Smith, H. H. Pegg and P. I. Tinkler.

Rebuilding: Interstate Oil & Refining Company is rebuilding a small plant in West Mule Creek field, Wyoming, destroyed by fire. Will double capacity.

Operating: Rex Refining Company, Rapid City, South Dakota, has completed installation of a small skimming plant, to process Osage field crude.

Operating: Mountain Fuel Supply Company, subsidiary Ohio Oil Company, is operating a small portable refinery at Hiawatha Dome, Northern Colorado.

Refinery: Pan American Petroleum & Transport Company reported let contracts to M. W. Kellogg Company for construction of its 28,000 barrel combination skimming and cracking installation to be located on Houston ship channel.

Improvements: Pure Oil Company, Marcus Hook, Pennsylvania, is overhauling various towers on its tube still units and installing new reflux tubes.

Rebuilding: Wilson Oil & Gas Company, Pampa, Texas, is progressing in reconstruction of its 2500-barrel refinery destroyed by fire early in March.

Reforming Unit: Pure Oil Company, Toledo, Ohio, is progressing nicely in construction of its new reforming unit, work being ahead of schedule.

Refinery: Petroleum Refiners, Ltd., Edmonton, Alberta, Canada, recently organized, capitalization $50,000, reported planning small refinery.

Enlarge: West India Oil Co. (Standard Oil Company of New Jersey) enlarging its case and can plants and extending refinery at La Brea, Trinidad.

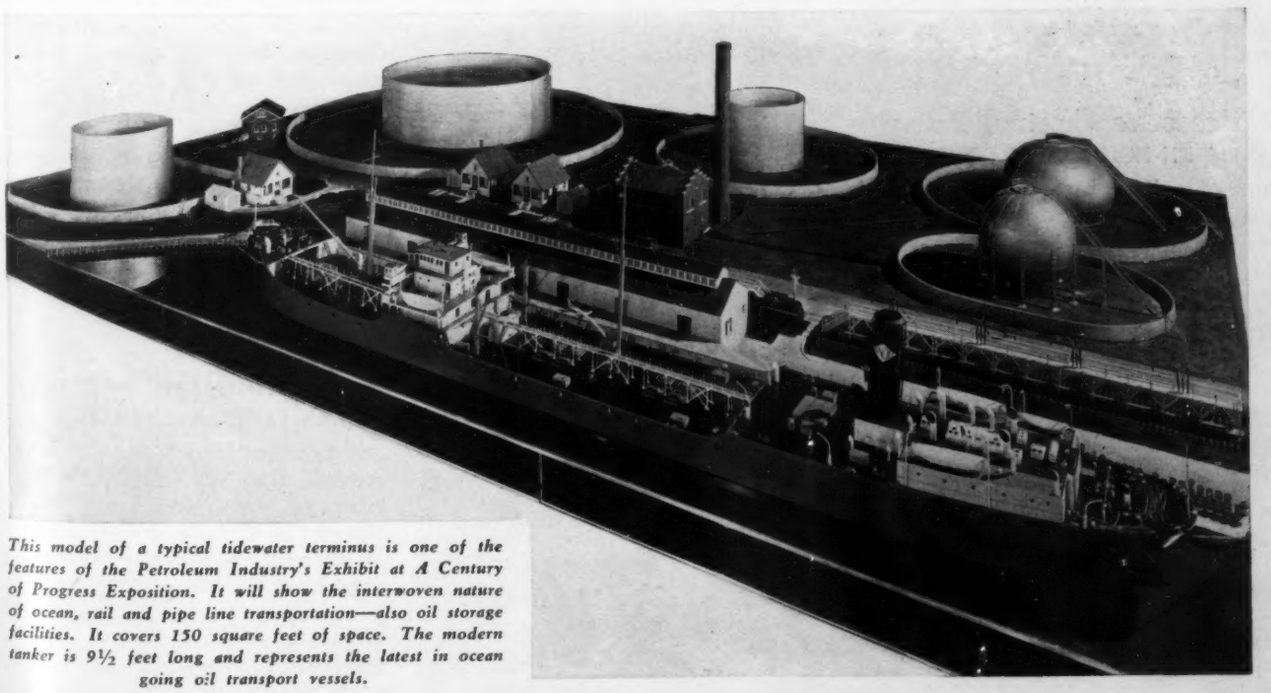
Fire Protection In Refineries

THE first edition of "Fire Protection in Refineries" prepared by the Committee on Fire Prevention of the Division of Refining, American Petroleum Institute, is now being distributed, after approval by the General Committee of the division. Copies are available from the institute headquarters at 250 Park Avenue, New York; price 75 cents. The book consists of three chapters and four appendices, covering fire protection design, operation and maintenance, fire fighting equipment, forces and practices, and data and typical examples illustrative of current practices in refineries. Users of this bulletin will find that the committee has done a most thorough and commendable job.

Airplane Fuel Made from Coal

Twelve months' supplies of a new petrol made from coal has just been contracted for by the Ministry of Air, for use by one of the British home defense air squadrons, according to a report to the Commerce Department from Trade Commissioner James Sommerville, London.

The new petrol is a by-product of an industry primarily making a smokeless fuel and is said to be cheaper than oil from coal made by a hydrogenation process. The company manufacturing the petrol is reported to have already made and marketed more than 4000 tons.



This model of a typical tidewater terminus is one of the features of the Petroleum Industry's Exhibit at A Century of Progress Exposition. It will show the interwoven nature of ocean, rail and pipe line transportation—also oil storage facilities. It covers 150 square feet of space. The modern tanker is 9½ feet long and represents the latest in ocean going oil transport vessels.

New Equipment for the Modern Plant

1. Check Valve

BARRETT, HAENTJENS & COMPANY

Barrett, Haentjens & Company, Hazelton, Pennsylvania, has introduced a check valve equipped with a mercoid flow switch, designated as the type "M" check valve.

Check Valve

The purpose of the switch is to shut down the pump in the event that it loses its water during operation. The switch is connected into the low-voltage coil of the motor starter, and is actuated by the valve flap. When the pump is in operation and delivering water, the flow through the valve raises the flap and closes the switch. When the pump loses its water the flap falls, the switch opens and stops the pump.

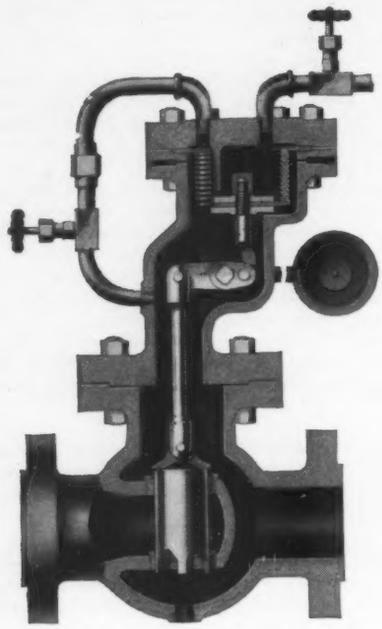
The switch can be arranged for either horizontal or vertical mounting of the valve.

2. Pressure Control Valve

NORTHERN EQUIPMENT COMPANY

Northern Equipment Company, Erie, Pennsylvania, announces production of a new design differential pressure control valve known as Copes Type SS-2, an improvement over Type SS.

Changes in the internal construction of the valve allow throttling higher pressure drops than in the earlier design, according to the manufacturer. Type SS-2 is made in sizes ranging from three quarters to six inches in the 250, 400 and 600 pound pressure standards. Range of control is 10 to 35 pounds per square inch differential pressure. Fittings are furnished in Monel metal or stainless steel.



Northern Pressure Control Valve

3. Threader

THE BORDEN COMPANY

The Borden Company, Warren, Ohio, announces the 12-R "Beaver" ratchet, a self-contained, adjustable one- to two-inch threader, or die stock. The manufacturer claims the dies are fully adjustable for over, under, or standard threads of full length. The 12-R weighs about 16 pounds, is made of malleable iron, and will perform equally well on steel, iron, cast iron, brass or copper pipe. With two handles, the ratchet sells for $16.00.

4. Portable Manhole Ventilator

COPPUS ENGINEERING CORP.

Coppus Engineering Corporation, Worcester, Massachusetts, announces a gasoline engine driven blower for ventilating and driving off obnoxious gases from manholes, tunnels and other enclosed places where electric power is not available.

Coppus Blower

The new device, which is powered by a three-fourth horsepower air cooled gasoline engine, operating at 1800 r.p.m., is mounted on heavy coil springs to cushion the vibration of the single cylinder engine, and delivers 1550 cubic feet of air per minute, according to the manufacturer. By means of an 8-inch diameter flexible tubing, of proper length, the air flow can be directed to any desired point. An adjustable discharge eliminates elbows in this duct.

The device weighs 105 pounds and can easily be carried around and set up on any space two feet square, or larger, for ventilating cable manholes, tunnels, pipe galleries, underground passages, coal pockets, shipholds, process tanks, etc.

5. Combustion System

NEILAN COMPANY, LIMITED

Neilan Company, Ltd., 641 Santa Fe Avenue, Los Angeles, California, (Division of Mason Regulator Company) announces a newly perfected compensated combustion control system which consists of two parts.

The upper instrument is a compensated boiler pressure controller, while the lower and larger is the compensated draft controller. The system is suit-

— — — — — — — — *MAIL COUPON* — — — — — — — —

REFINER AND NATURAL GASOLINE MANUFACTURER,
Houston, Texas, U. S. A.

Please see that I am supplied, without obligation, additional information on New Equipment Items Nos..... .....described in May, 1933 issue of REFINER.

Name .....

Company .....

Address .....

able for oil fired, stoker fired or pulverized coal installations.

The system functions so as to render boiler control automatic. It controls

Neilan Boiler Control

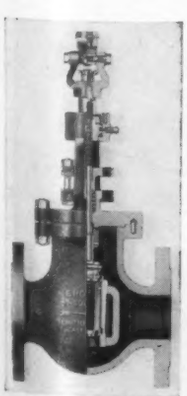
the supply of fuel, regulates the speed and position of dampers or blowers or combinations of the two.

The instruments are furnished on a suitable attractive panel board with a special manual control feature which permits either to be thrown out at will and the boiler controlled automatically. The system utilizes compressed air as an operating medium, and for this reason the panel board may be removed from the boiler room to a centralized control room when desired.

6. Cast Steel Throttle Valve

KEROTEST MANUFACTURING CO.

Kerotest Manufacturing Company, Pittsburgh, announces a new cast steel, balanced throttle valve made in three-inch size with flanges 10 inches in diameter to suit every type of twin engine.



Kerotest Valve

The manufacturer states the valves are "quick opening, have sensitive control, operate easily, are perfectly balanced, have non-corrosive internal working parts, and are made for high or low pressure, for superheated or saturated steam service."

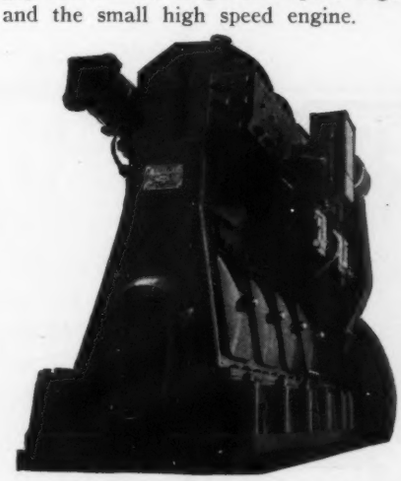
Plug and cake are of a special steam-resistant alloy. The manganese bronze stem nut is fitted with double thrust ball bearing to eliminate friction and strain. Thrust bearings and stem thread are alemite lubricated. Stem and connection pin are heat-treated stainless steel and the body and bonnet are cast steel. The area-way through the valve is 25 per cent greater than the area inside the three-inch pipe.

7. Vertical Gas Engine

NATIONAL TRANSIT PUMP & MACHINE COMPANY

National Transit Pump & Machine Company, Oil City, Pennsylvania, announces a new vertical four-cycle gas engine. This new engine now enables them to furnish engines ranging in size from 20 to 1500 horsepower.

The new vertical engine, while being sold as a gas engine, is so designed that it can readily be changed to a solid injection Diesel engine at any time. It operates economically and efficiently on either natural gas or refinery gas, according to the manufacturer. It is a moderate speed engine for heavy duty service and long life, and was designed to fill in the gap between the large slow speed engine, and the small high speed engine.



National Transit Vertical Engine

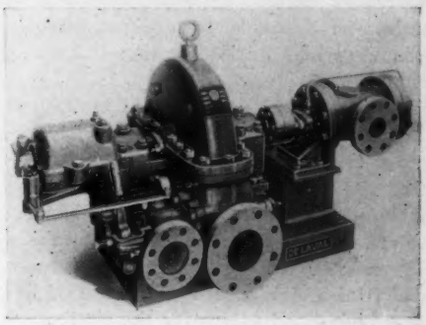
This engine is also equipped with the regulating valve mechanism which has proved successful on the horizontal type engines. One of the features of this engine is its automatic lubrication system which continuously filters and water-cools the oil before admitting it to the engine.

The new vertical engine can be furnished with two, three, four, or six cylinders, ranging in size from 20 to 100 horsepower.

8. Displacement Pumps

DE LAVAL STEAM TURBINE CO.

De Laval Steam Turbine Company, Trenton, N. J., has announced a new line of IMO turbine and motor driven rotary displacement pumps for oil burners specially designed for delivering oil to burners at constant pressure.



De Laval Steam Turbine Pump

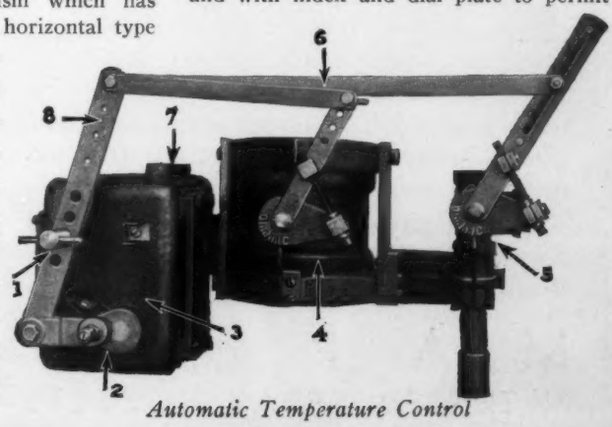
Direct supply of oil to burners from pumps directly coupled to steam turbines or electric motors simplifies equipment and operation of oil fired furnaces. Continuous rotary displacement pumps of the type shown in the illustration, it is said, do not set up pulsation, and when turbine driven are readily controlled to develop constant pressure, irrespective of the number of burners used, by use of a pressure governor to regulate turbine speed.

9. Two Position Controller

AUTOMATIC TEMPERATURE CONTROL COMPANY, INC.

Automatic Temperature Control Company, Inc., Philadelphia, Pennsylvania, has added to its line of motor operated controllers a new two position unit known as Type 2, which has sufficient power to handle an air valve up to four-inch size in combination with one half-inch fuel oil valve or to handle two valves up to four-inch size as a unit on low pressure gas and air.

Where furnace atmosphere is important, valves having similar characteristics are provided, each equipped with micrometer screw adjustment for minimum setting and with index and dial plate to permit



Automatic Temperature Control

readily duplicating previous settings. Maximum settings for both fuel and air valves can be obtained by adjusting the connecting links (6) where attached to the valve levers, and where attached to the main operating lever (8).

With the valves adjusted for desired combustion, the fuel-air ratio is maintained throughout controller stroke. Both valves are moved simultaneously and in unison—a desirable feature not possible where springs or lost motion linkage is employed.

A feature which is standard with Type 2 controller is the ability to quickly remove the fulcrum stud (1), thus permitting the attendant to manually move the main operating lever, with attached valves to any desired position. This feature is a convenience when starting up a furnace and it also eliminates the expense of bypass piping and valves for the air line.

Where full pipe line capacity is required, and tight shut-off is essential, Type 2 controller can be supplied to operate valves of globe body type in sizes up to three inches, for pressures up to 250 pounds per square inch. Where the medium is at lower pressures, Type 2 controller has sufficient power to handle larger valves of globe body type. These valves can be provided with an adjustment feature permitting any desired minimum setting up to 50 per cent of valve capacity.

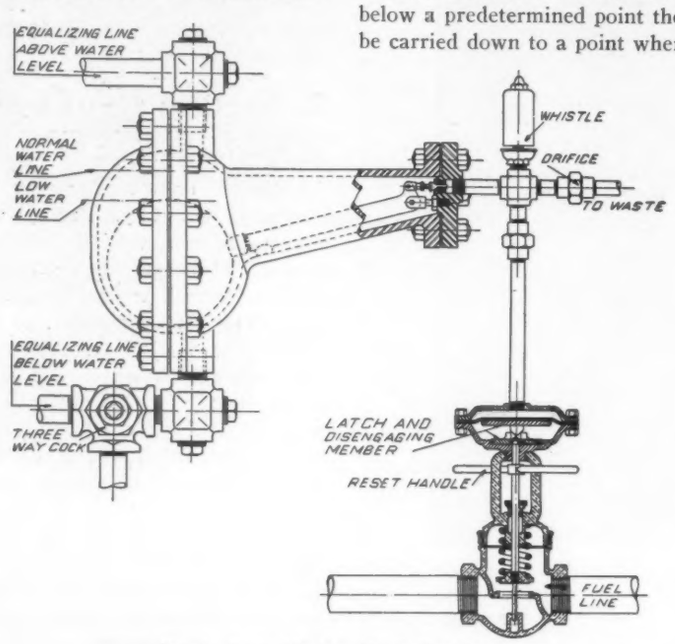
10. Protective Unit for Boilers

DAVIS REGULATOR COMPANY

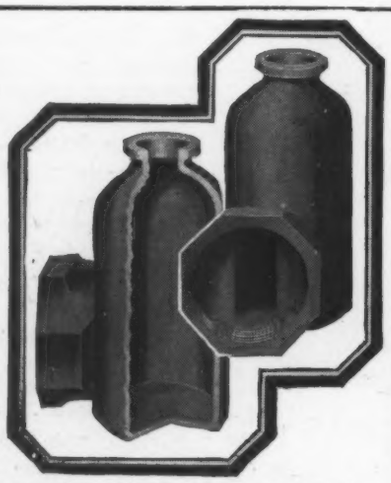
Davis Regulator Company, Chicago, has recently developed an automatic low water fuel cutoff designed to meet insurance standards for gas fired field boilers such as are used in drilling oil and gas wells.

The unit consists of a cast steel float chamber, pilot valve, fuel shutoff valve, and a whistle. The float chamber is connected to the steam and water spaces of the boiler. The diaphragm-operated fuel valve may be placed at any convenient point as it is closed by admission of steam pressure to the top of the diaphragm. The unit is designed to handle a maximum working steam pressure of 350 pounds.

When the water level in the boiler drops below a predetermined point the float will be carried down to a point where it opens



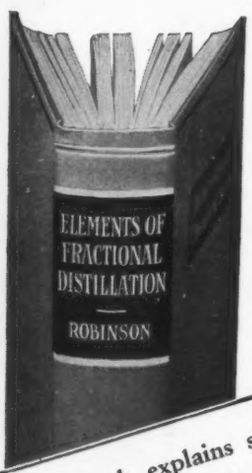
Davis Low Water Fuel Cut Out



IT doesn't cost a cent more to save money with Marley patented spray nozzles. Their finer, more uniform spray under low pressures does a better cooling job at lower pumping cost. Their price is no more than that of ordinary nozzles.

It will pay you, too, to specify and use them. The Marley Company, 1737 Walnut, Kansas City, Mo.

M A R L E Y
PATENTED SPRAY NOZZLES



Elements of Fractional Distillation

By
Clark Shove Robinson
Assistant Professor of Chemical Engineering, Massachusetts' Institute of Technology

$3.00

This book explains simply and accurately, according to the best ideas of physical chemistry and chemical engineering, the principles of fractional distillation, illustrating these principles with carefully selected applications.

204 pages
5½ x 8, illustrated.

INTERNATIONAL CHEMICAL SERIES

GULF PUBLISHING COMPANY
P. O. Box 1307
HOUSTON, TEXAS

the pilot valve. Steam flowing through the pilot valve builds up pressure over the diaphragm of the cutoff valve and forces it down. The downward movement of the diaphragm trips a latch and causes the main valve to close immediately. After closing, the main valve cannot be opened again until the latch is reset by hand.

A whistle is installed between the float chamber and the cutout valve; when the pilot valve opens the whistle blows, warning attendants. A small vent orifice is provided in the line between the pilot valve and the diaphragm chamber that prevents any possible leakage from building up enough pressure to trip the fuel valve. The vent is kept very small so that it does not interfere with the regular operation of the unit.

Facilities for testing the unit at any time are provided by a three-way cock located in the water leg of the float chamber. Movement of this cock drains the water out of the float chamber and allows the pilot valve to open, thereby starting the cycle of operation. Steam blowing through the cock after the water is drained out makes it impossible not to notice the position of the handle. This insures that the cock will be turned back to its normal operating position. As a further safeguard, the main fuel valve cannot be reopened as long as steam flows through the float chamber.

11. Dial Type Indicator

MOREY & JONES, LTD.

Morey & Jones, Ltd., Los Angeles, California, announced a new dial type indicator or gauge, designed to fill the need for a reasonably priced instrument for indicating rates of flow and differentials and level indications.

Morey & Jones Indicator

The indicator is a mechanically-operated, direct reading dial gauge—actuated by a metallic bellows located in the small chamber in rear of the dial case. Dial is large and has large, distinct figures, readily discernible even at a considerable distance. Calibrations of dial may be furnished reading in inches differential—or in G.P.M. of flow, or other direct readings for flow service as required, at no extra cost.

Specific features of construction include: simplicity of the various mechanical parts, stem, links, and connections to pointer arm—obviating servicing troubles attendant on complicated mechanisms. A packing gland on a very small shaft, connecting motion of bellows stem to pointer arm, effectively serves to keep liquid from the dial case. Suitable "stops" are provided to prevent injury to pointer if instrument is subjected to a greater differential than that for which it is calibrated.

An outside zeroing adjustment for checking zero position of the pointer readily, without disassembling instrument. The spring employed for resisting the differential pressure is arranged to allow a simple calibration at the factory, for the particular range required.

The indicator is built to withstand 250 pounds per square inch maximum working pressure; and is now manufactured for differential pressures ranging from about five inches of mercury to 25 pounds.

Indicator is suitable for operation from

PITTSBURGH PIPING CREASED BENDS *for* EXPANSION LOOPS » »

SEVERAL features of Creased Bends merit the attention of refinery engineers.

1. They are more flexible.
2. They require less space.
3. They maintain original wall thickness throughout.
4. They reduce stress on adjacent joints.

Creased Bends are available in all sizes for every pressure.

If you haven't a copy of Bulletin B-201, which contains data on Creased Bends, we will be glad to send you one.

12¾" O.D. x ⅜" Wall Thickness Seamless Steel Pipe.

PITTSBURGH PIPING AND EQUIPMENT CO.
43RD ST. & A.V.R.R. PITTSBURGH, PA.

P P & E Co.

BRANCH OFFICES
Indianapolis New York
San Francisco Chicago
Cleveland Detroit
Houghton, Mich. Boston

SMALL in SIZE *Great Otherwise!*

When rough usage and severe service demand the utmost in vise dependability, you'll find this unbreakable "Vulcan" without equal.

Williams' "Vulcan" Vise is made throughout of wrought steel with *drop-forged* jaws, base and handle. No castings whatever are used in its construction. Compact in design, it is light-weight and convenient to use—rapid in its action and positive in grip. Chains are of GENUINE "Vulcan" quality.

Williams' "Vulcans" are available in four sizes for ⅛" to 8" pipe. Like all Williams' products they are fully guaranteed. Literature will be furnished on request.

Buy from your distributor.

J. H. WILLIAMS & CO.
"The Drop-Forging People"
75 SPRING ST.,
NEW YORK, N. Y.

Western Warehouse, Sales Office: **Chicago**
Works: **Buffalo, N. Y.**

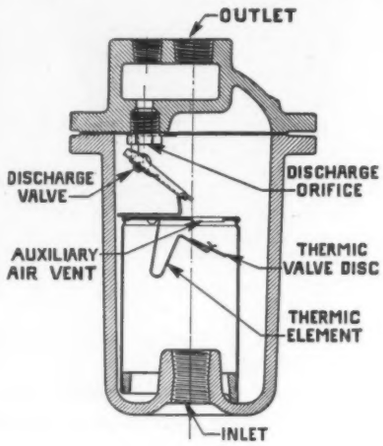
GENUINE
WILLIAMS
SUPERIOR DROP-FORGED TOOLS
VULCAN
DROP-FORGED
CHAIN PIPE VISE

any standard orifice, Venturi tube, nozzle, or other means of creating a differential.

12. Steam Trap

ARMSTRONG MACHINE WORKS

Armstrong Machine Works, Three Rivers, Michigan, has developed an automatic air by-pass to promote quick heating and integral with the Armstrong inverted bucket steam trap. For quickly removing air from jacketed kettles, reboilers and pipe coil radiation, the company offers a special trap bucket having a very large auxiliary air vent. This vent is closed by a flat disc of stainless steel on the end of a strip of rustless thermostatic bi-metal



Armstrong Trap

which in turn is double riveted to the bucket cap. As long as the trap is cold, the disc is held away from the vent and air escapes so rapidly that the bucket cannot float and close the discharge valve. Air blows through until steam fills the radiation and reaches the trap causing the thermic strip to seat the disc which prevents steam from escaping through the auxiliary vent. Thereafter, the trap functions in the normal manner and any air that may be mixed with the steam will escape through the standard fixed vent.

13. Sound Isolating Base

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, announces a new motor base with sound-isolating features.

Floating members are suspended on specially developed isolating material. The motor is mounted as on a standard sliding base, and belt tension and motor alignment are maintained in the ordinary manner.

Adjusting screw moves motor for belt adjustment. Bases are installed as a unit. The stiffness of the sound-isolating material is sufficient to maintain motor alignment for any reasonable belt tension. Guide washers in machined grooves are used with the belt-adjusting feature to maintain motor alignment.

14. Rubber Lined Valve

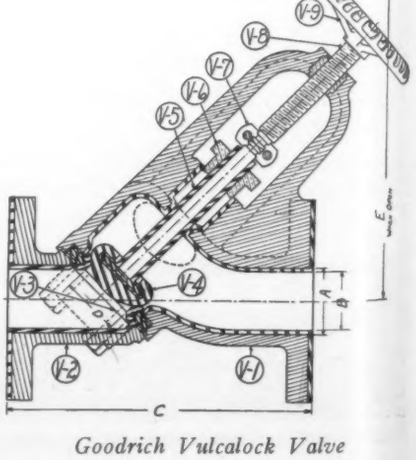
THE B. F. GOODRICH RUBBER CO.

The B. F. Goodrich Rubber Company, Akron, Ohio, announces the Vulcalock valve, designed for handling corrosive and abrasive fluids under conditions of high pressure, pulsating pressure, throttling or suction.

The valve is rubber lined with standard Goodrich Acidseal compounds, hard or soft, depending upon conditions to be met.

Action of the valve does not depend upon a flexible diaphragm. The resilient, rounded disc which snaps over a circular plate at the lower end of the stem provides a seal when brought into contact with the molded rubber-covered seat.

Engineering features listed by the manufacturer are: Acidseal lining of valve bonded to metal parts with practically integral adhesion by patented Vulcalock process. Corrosive or abrasive materials come in contact only with rubber especially designed to resist their deteriorating action. Nearly straight line of flow makes the valve especially adaptable to fairly high pressure work and abrasive service. On sizes up to and including six-inch, there is no restriction of flow through the seat ring. Resilient molded disc which snaps over circular plate at lower end of stem readily replaceable at very low cost. Molded seat ring, double seated and reversible for double service, can be easily removed. Can be quickly changed from a straightway to angle valve or vice versa by removing body bolts, reversing the lower body section and replacing the bolts. Cast iron body of fundamentally new, two-piece Y construction, simple, rugged, designed to withstand working pressures up to 150 pounds per square inch. Operating screw of best quality bronze, engaging a thread bushing of bearing bronze cast into the iron yoke. Attached to upper end of valve stem by simple swivel coupling. No torsional stress on the stem either in opening or closing of valve. No rotary motion of stem through stuffing box. No "bonnet"



Goodrich Vulcalock Valve

on valve, stuffing box being cast integral with main or upper section of body, making alignment of disc simple and positive. Stuffing box of ample size. When valve is in wide open position, back of resilient disc seals off stuffing box, which can be repacked while valve is under pressure. Bronze gland operated by two stud bolts attached to valve body. Both stud and body bolts of heat treated steel. Valve may be taken apart completely and easily and quickly reassembled without special tools. Disc and seat removed and replaced with especial ease.

15. Compensated Air Cell

BROWN INSTRUMENT COMPANY

Brown Instrument Company, Philadelphia, has developed a new type of battery for use with the Brown potentiometer, which eliminates frequent standardizing. This new battery, the Brown Compensated Air Cell, having a constant current output and a life of over 2½ years assures the potentiometer user of continuous accuracy with minimum attention. It can be used with all types of Brown potentiometers.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

Of The Refiner and Natural Gasoline Manufacturer, published monthly at Houston, Texas, for April 1, 1933.

State of Texas, County of Harris: ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared A. L. Burns, who, having been duly sworn according to law, deposes and says that he is the Business Manager of the Refiner and Natural Gasoline Manufacturer and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: R. L. Dudley, 3238 Huntington Drive, Houston, Texas.

Editorial Director: S. W. Robinson, 5002 Scotland, Houston, Texas.

Editor: Grady Triplett, 2202 Dunstan Road, Houston, Texas.

Managing Editor: J. Kent Ridley, 605 Sul Ross, Houston, Texas.

Business Manager: A. L. Burns, 4311 San Jacinto, Houston, Texas.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

The Gulf Publishing Company, Houston, Texas; James Anderson, Houston, Texas; R. L. Blaffer, Houston, Texas; Mrs. Sarah Campbell Blaffer, Houston, Texas; A. L. Burns, Houston, Texas; J. F. Carter, Jr., Tulsa, Okla.; Dr. N. L. Dudley, Goose Creek, Texas; R. L. Dudley, Houston, Texas; W. S. Farish, Houston, Texas; Wm. V. Gross, Houston, Texas; Howard R. Hughes, Houston, Texas; Chas. H. Lane, Houston, Texas; Wallace E. Pratt, Houston, Texas; J. Kent Ridley, Houston, Texas; S. W. Robinson, Houston, Texas; Mrs. Maude G. Sterling, Houston, Texas; R. P. Swinsky, New York, N. Y.; O. R. Waller, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

A. L. BURNS,
Business Manager.

Sworn to and subscribed before me this 31st day of March, 1933.
(Seal)

J. KENT RIDLEY.
(My commission expires June 1, 1933.)

16. Welding Process

METAL & THERMIT CORPORATION

Metal & Thermit Corporation, 120 Broadway, New York, announces a new welding process known as Murex Straight Gap welding, particularly suited to the joining of heavy plates.

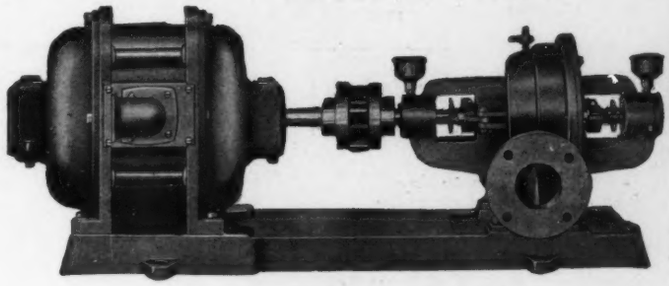
According to the corporation, the new process does away with all need for "veeing" or grooving of plate edges, and the plates may be used just as they come from the mill.

The electrode used in the process is Murex Universal, for use on mild steel in flat, vertical, or overhead work.

Neilan Company, Ltd., manufacturers of automatic regulating and control equipment, announce the opening of a new office in Philadelphia at 930 North Front Street. Mr. M. N. Aitken has been transferred from the Neilan Chicago office and will be in charge of Neilan sales in Philadelphia. Mr. Aitken has been connected with the sale of Neilan equipment for several years. For the past year he has specialized on control problems of the gas industry.

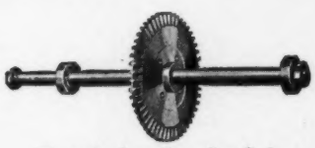
J. P. Devine Manufacturing Company, of Mt. Vernon, Illinois, announces a change in its New York office location from West 43rd Street to Room 603, 205-17 East 42nd Street, R. E. Lemire, agent, and a change in its Chicago office from 105 W. Madison Street to Room 1104, 307 North Michigan Avenue, F. R. Murphy, agent.

STANDARD
WESTCO
TURBINE
PUMP



SAVE MONEY
on Corrosion Resisting Pumps!

Pumping Costs Lowered By WESTCO'S Small Metal Requirements



Westco's Impeller—Its Only Moving Part

BECAUSE the Westco Pump is so simply constructed — and because it has only one moving part — the low material cost of making the Westco from even the most expensive alloy is another important feature that merits your consideration.

Westco Pumps are being most economically made from a number of acid, heat and corrosion-resisting alloys. Among them are KA2, Stainless Steel, Durimet, Illium, Monel Metal, Ni-Resist and Bronze. Westco's ability to produce higher pressures in single stage avoids a great deal of costly multi-stage construction.

In the oil industry wherever pumping duties require the use of resistant alloys, Westco pumps are successfully meeting the most exacting requirements.

Does Not Vapor Bind

With the Westco Turbine Principle of pumping, you are assured of a steady non-pulsating flow at all times — this pump cannot become vapor bound.

Furthermore, Westco possesses the valuable ability of *automatically adjusting itself* to changes in the operating conditions.

Send for Details

Fill in the coupon below and *mail today* for Performance and Selection Tables together with complete engineering data. WESTCO PUMP CORPORATION, Davenport, Iowa. *Branches:* New York, Chicago, Philadelphia and San Francisco. *Representatives in 50 Principal Cities.*

MAIL TODAY

WESTCO PUMP CORPORATION,
Davenport, Iowa, Dept. N-5.

Gentlemen: Without obligation, please send Performance and Selection Tables for Westco Turbine Standard Pumps and Hot Oil Pumps.

Name .....

Address .....

City .....

State .....

WESTCO *TURBINE* PUMPS

HIGH PRESSURE - - - SINGLE STAGE

Now Is the Time

TO RE-COVER YOUR FILTER LEAVES WITH LONG LASTING

SMOOTH-TEX

METALLIC FILTER CLOTH

You can do the work, using our improved method and fittings or we do it for you.

Write to-day

MULTI-METAL WIRE CLOTH CO., INC.
795 EAST 139TH ST.
NEW YORK, N. Y.

Ask for List

Ask for list of refiners now using the CAMPBELL Boiler Feedwater Regulator.

Patented

Refiners prefer the CAMPBELL because of its many exclusive features and its positive dependability. Nothing to get out of order. No floats. No thermostats. No generators. No moving parts in the Regulating Element. The *only* regulator operated by direct boiler pressure. The only regulator having an indicator, etc. Get complete data. Use coupon below.

ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE
275 South St., Newark, N. J.

Clip this to your letterhead, check the items in which you are interested, and we will gladly send prices and data. No obligation.

- ☐ The Campbell Boiler Feed Water Regulator
- ☐ Reducing Valves
- ☐ Damper Regulators
- ☐ Exhaust Control System
- ☐ Temperature Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

ITEMS ABOUT MANUFACTURERS

Foster D. Snell, Inc., chemists and engineers, have moved to 305 Washington Street, Brooklyn, New York, where larger quarters have been provided for offices and laboratories. Executive offices are on the sixth floor with laboratories located on the ninth floor of the building.

Republic Steel Corporation has closed its Dallas, Texas, district sales office and moved to 2322 Gulf Building, Houston. R. E. Lanier, district sales manager and his present staff are in charge of the new Houston office.

George L. Mesker & Company, Evansville, Indiana, manufacturers of sectional steel buildings announces appointment of Maxwell-Butler Company, 2519 Commerce Avenue, Houston, as distributors and sales agents.

Ludlow Valve Manufacturing Company, Troy, New York, announces appointment of John L. Sybrandt as western sales manager, with headquarters at Chicago. He will be in charge of sales west of the Mississippi River, including the Pacific Coast.

At the same time the company announces appointment of Joseph W. Fitzpatrick as district manager of the Kansas City district.

JOHN L. SYBRANDT

Mr. Sybrandt has been with the Ludlow organization since 1905, having been district manager of the Kansas City offices since 1907. Mr. Fitzpatrick has been with the organization for 21 years.

Worms & Company, the French associate of Chicago Bridge & Iron Works, has a shipbuilding plant at Le Trait near Le Havre, and is just completing construction and erection of a refinery program involving 60 Wiggins floating roofs and some tankage for Standard Oil Company (New Jersey) and the Vacuum Oil Company, at Port Jerome, and for the Anglo-Persian Oil Company, at Martigues near Marseilles.

American Manganese Steel Company, Chicago Heights, Illinois, is discontinuing the registered trade name "Fahralloy" and in the future will sell its Nickel-Chromium Alloys under the trade-name "Amsco Alloys."

Byron Jackson Company, Berkeley, California, announces removal of its Mid-Continent offices from Tulsa to 2505 Boaz Street, Fort Worth, Texas, with Lynn Sawyer in charge.

Marley Company, 1737 Walnut Street, Kansas City, Mo., has recently issued a new bulletin No. 40 describing in detail with illustrations its spray deck type cooling towers.

Neilan Company, Ltd. (Division of Mason Regulator Company), announces the opening of a new office in Baltimore, Maryland. O. H. Seal, an engineer with several years oil and control experience, will be in charge of this office which will be located in the Whitaker Building. Mr. Seal will serve the Baltimore territory with Neilan regulating equipment and Mason-Neilan compensated temperature, pressure and flow control instruments.

Walter E. Lummus died at his home in Montclair, New Jersey, on March 31. Mr. Lummus was born at Lynn, Massachusetts, November 30, 1867, and was the founder of the Walter E. Lummus Company, well known in the chemical and petroleum industries as engineers and builders of distillation plants. Mr. Lummus was a pioneer in the design and development of modern distillation equipment in this country. He retained an active connection with The Lummus Company until the day of his death.

Timken Michigan "Screw-Lift" Plug Valves will, in the future, be marketed through the Pittsburgh Equitable Meter Company and the Merco Nordstrom Valve Company, a subsidiary, at all branch offices.

Timken Michigan "Screw-Lift" Plug Valves, regularly furnished in Meehanite Metal, are particularly well adapted to high pressure and extreme temperatures, according to the manufacturer.

Electrically Driven Centrifuges
Hand Centrifuges
WRITE
WILLIAMS, BROWN & EARLE, Inc.
Manufacturers of Laboratory Apparatus
918 Chestnut St. Philadelphia, Pa.

PATENTED
PULMOSAN SAFETY EQUIPMENT CORPORATION
176 Johnson St.
Brooklyn, N. Y.

PULMOSAN SAFETY DEVICES

- RESPIRATORS
  Dust—Smoke—Fumes
- GOGGLES
- FIRE FIGHTING

Write for complete file of safety data.

EVERYTHING for SAFETY